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What the West Offers

IT will soon be time for those engineers who will attend the International Engineering Congress, Sept. 20-25, to make plans for their trip to San Francisco. Some will go by special train and others by individually selected routes, but no matter what course is chosen opportunities along the wayside should not be neglected. The cities between Maine and the Pacific Coast are filled with interesting things to see, particularly from the engineer's viewpoint, and the time spent in looking over the work in new localities will be decidedly profitable. But a man arriving in a strange city is often at a loss to know what engineering works it contains and so, unguided, he may miss the very structure which would best repay a visit of inspection. To minimize this possibility the Engineering Record presents on page 261 a guide to the more important engineering works in municipalities en route to California. The list is not complete, nor are the descriptions of the structures intended to serve any other purposes than hints as to what is to be seen. If the list can be utilized by engineers in adding to the pleasure and interest of their visit to the Exposition it will have fulfilled its object.

Employers' Rights and Responsibilities

THE court decisions indicating the trend of laws affecting labor, published by the Bureau of Labor Statistics and reviewed on page 217 of last week's issue of this journal, are merely indicative of the state of mind on the part of legislators and on the part of courts interpreting statutes enacted for the protection of labor. It will not do, however, to assume that the trend is all one way, for there is no more significant or important decision cited than that in the case of *Coppage vs. Kansas*. In that case, it will be recalled, Justice Pitney of the U. S. Supreme Court disposed of the statute, typical of many others, in which it was sought to prevent employers from refusing to employ members of labor organizations. This decision read again is no less inspiring than it was at the time of its announcement last year. It deserves to be considered the Magna Charta of employers as determining their rights and responsibilities in dealing with employees.

Special Building Permits

ONE of the provisions in the stairway regulations in Cleveland, noted on page 260, allows the building commissioner to issue permits governing the construction of stairways other than those required by law. The stairway must be of incombustible material and must not endanger life or create a fire hazard. Along with

the other definite provisions, which have been placed in the building code only after careful first-hand investigations, this is an excellent example which might well be followed in many another code. The practice of getting one's alderman to have the City Council pass a special ordinance permitting a violation of the code, thus by-passing the official whose business it is to express an opinion on the subject, is the more usual and less satisfactory way. When matters of special design must be decided the judgment of a trained man ought to be regarded as final. Certainly the untrained layman alderman, if he is fair, would want all the honest expert opinion he could get before voting for a violation permit, so why bother the aldermen at all?

A New Philippine Road

THE abandonment of the once famous Benguet road, constructed only a decade ago at a cost of \$2,000,000, in favor of the much cheaper and more useful Baguio-Bauang road, which is described on page 264, cannot fail to impress one with the quickness with which American engineers adapt themselves to new conditions. When the Benguet road was built it was thought that a very difficult problem had been solved in the most economical manner, but those who located it had very little reliable information beyond that which their own surveys revealed to them. In a country where rainfalls of extraordinary intensity are frequent, the existing data did not prove sufficient. In the course of the last ten years it has cost a million dollars to maintain the Benguet road, due in large part to flood damage. In locating the Baguio-Bauang road at a high level beyond the reach of flood waters the engineers have not only profited by the lessons learned from the old road, but have found a much better route from Baguio to the sea. The old road was, in many respects, built as an American road would be built. The new road is adapted to Philippine conditions as evolved by the engineering force of the Bureau of Public Works of the islands since the American occupation.

Foundations on Clay Strata

THE results of further careful examinations at the site of the landslide and subsidence at the plant of the Knickerbocker Portland Cement Company near Hudson, N. Y., confirm the first report of the probable cause given in this journal Aug. 7, page 179. The article by Assistant State Geologist D. H. Newland, on page 253, makes it clear that this remarkable disturbance was not a landslide of the familiar kind. Instead, the unusual sub-surface

softening and flow of the deeply underlying bed of blue clay, due to an excess of water, resulted in the sudden breaking down of the harder overlying strata which were supporting the load and the squeezing out of the softened mass. Such an occurrence confirms the soundness of a policy of consulting geologists and making extensive examinations of the geological conditions whenever permanent engineering structures are to be constructed at sites known to be subject to geological disturbances, or where unusual conditions exist liable to cause failures. It is evident that piles in such a case as that at Greenport would be of little, if any, value. In fact, rows of piles had been driven on this site between the power house and creek, and showed little restraining effects. The final suggestion of Mr. Newland that a preventive measure for such conditions is thorough drainage of the subsoil is of direct value to engineers, although it might be found impracticable to apply it under existing local conditions.

An Encyclopedia of Engineering

FOR those who examined, in last week's issue of this journal, the partial list of papers to be presented next month at the International Engineering Congress in San Francisco the significance of the coming meeting needs no emphasis. The program speaks for itself. Never before has there been assembled a collection of technical papers which covered the field so completely and included in the list of authors so many of the highest authorities in various branches of engineering. In addition to the interest which the individual papers command on their own merits, the group of titles under each classification has been chosen and then assigned to the men best qualified to discuss them so that each field is adequately provided for. With the addition of such discussion as is to be expected there will be produced an encyclopedia of modern engineering practice which will be invaluable in a reference library. Nothing less than this, however, was to have been expected from those loyal workers, all men of noted engineering attainment, whose best efforts have been put into service on the various committees and to whom great credit is due for the collection of so representative a list of papers in spite of war conditions which, at first, raised the question of advisability in attempting to hold the Congress at all. All the more credit is due because this has been entirely a labor of unselfishness and has required arduous and seemingly thankless service for a period of over two years. During this time the heaviest burden has fallen upon the committee of management in San Francisco, each member of which has placed the

best interest of the Congress paramount. The list of titles and authors speaks so well for the achievement of those who selected and assigned the subjects and contains such assurance of the benefits to be derived from attending the meeting that the success of the Congress is assured.

Highway Economy

THE cost of doing what the engineer prescribes is so often pared down by someone else that it is refreshing to find the cost of a structure, on which strictest economy was necessary, left entirely to the judgment of the engineer in charge. It is notable, also, that in this case he met the requirements exceptionally well both as to cost and suitability of design. The Yolo Causeway, described on page 248, will bring one of the main trunk lines of California into the State Capital, and bridges a flood channel of the river 3 miles wide. It was acknowledged that if \$1,000,000 or \$1,250,000 were available for a reinforced concrete viaduct of some standard design there would have been no problem at all in building a permanent structure whose appearance would be a credit to the highway commission, but with considerably less than half a million dollars to work with the question of suitable design was another matter. However, by working out a highly economical scheme for a floor system of concrete slabs cast in a yard, and placing these on concrete piles driven as in railroad trestle construction, it was found possible to build the greater part of the structure entirely of concrete and to get the job done for a total of \$393,000. Of course, it was necessary to adopt certain expedients in the construction which were more or less experimental, and probably on another structure designed along similar lines the methods would be somewhat different. But certain it is that much credit is due Austin B. Fletcher, chief engineer of the California Highway Commission, for successfully extending into the field of long highway bridges the economy for which he has already become famous in road building.

Reforms Suggested by Commerce Commissioner Harlan

CONCURRING with the minority report of Commissioner Daniels in the Western rate-advance case, Commissioner Harlan incidentally suggested several ideas that are worthy of serious consideration. He thinks that too much time and labor are expended in these recurring rate contests and that some way should be found for arriving at results more promptly. He believes the commission should have power to fix minimum as well as maximum rates. The commission should have more effective control, he thinks, over rates initiated or compelled by State authorities. An attempt should be made to establish a uniform classification upon a normal basis, applicable throughout the entire country, and with it a normal rate structure having sufficient elasticity to allow for varying operating costs, density of traffic, circuitous routes, competitive and other conditions un-

der which transportation is conducted in different parts of the country.

All of the above suggestions are in accord with common sense, with the views of able railroad men who have given the subject much thought. The time and labor to which the railroads and shippers are put in preparing the rate cases, the impossibility of the commission more than partly digesting these assembled data, the exclusion from the careful consideration of the commission of many important minor cases because of the time required by the major cases, the utter failure of the present system to meet emergencies by emergency measures—these are all facts that argue eloquently for Mr. Harlan's first suggestion. The injustice of a regulatory system that regulates in one direction only is shown strikingly enough in the Ulster & Delaware passenger-mileage case, commented on in the Engineering Record of Aug. 7, page 154, and set forth more fully on page 226 of last week's issue, wherein the New York Public Service Commission has declared itself powerless to relieve the railroad from the necessity of carrying passengers below cost. The connection between interstate and intrastate rates is so close that it seems to be only a question of time before authority over all rates will become vested in a Federal body. And the uniform classification and normal rate structure seem to be just what would result if a system of regulation could be devised whereby the best railroad rate experts could work in complete harmony with one governmental body big enough and with broad enough powers to meet every railroad issue squarely.

Shrinkage and Time Effects on Concrete

THE EFFECT of shrinkage of concrete has been recognized, although its extent is not generally appreciated. The report of tests made by F. R. McMillan, an abstract of which is presented on page 251, will undoubtedly induce further investigation of this important subject. The results, however, may not be considered as conclusive. The number of specimens was small, and most of the tests were made on very shallow members with very long ratio of span to depth, so that the results cannot be directly applied to practice. While the conclusions seem alarming, the results are not as unfavorable as they appear at first inspection.

Other tests have given smaller values for the extent of shrinkage than those found by Mr. McMillan. Extensive tests made in Germany on concrete specimens setting in air show the maximum total shrinkage to be 0.000324 of the length. The rate of shrinkage is almost uniform for the first forty days, when it reaches about two-thirds of its total. After forty days the rate of shrinkage gradually decreases until it is almost negligible at the age of 200 days. These tests were made with concrete of the composition ordinarily used in construction, while in Mr. McMillan's tests pea-sized limestone was used. The German tests corroborate the swelling of the concrete caused by moisture.

In actual construction, as may be seen from experience, the effect of shrinkage is hardly ever serious. In most cases this shrinkage, as well as the temperature changes, causes shortening or lengthening of a reinforced concrete building as a whole without producing appreciable cracks. Of course, if the building is not properly designed and in cases where the piers or columns are not flexible and do not allow free movement of slabs and beams, cracks are apt to occur. By proper design shrinkage cracking can be reduced to a minimum, even if not wholly eliminated.

The conclusions given by the author as to the effect of shrinkage on compression members are not justified in view of tests of columns made at ages up to one year, reinforced with both vertical steel and spirals. In all cases the strength of the columns grows with age, which would not be possible if the steel, as presumed by Mr. McMillan, was under large initial stresses due to the shrinkage.

The novel part of the test is the time effect on the concrete under stress. Before any positive conclusions can be reached, however, additional tests must be made, especially on members under working conditions. In practice occasional sagging has been found, but this can usually be attributed to results in design rather than to the properties of the material. Of course, the high compressive stresses which are sometimes permitted at the supports in continuous beams and in flat slabs should be discouraged. The compressive stresses at these points should be computed and properly provided for. The use of compression steel in such cases would undoubtedly strengthen the construction and prevent any tendency to yielding, because any increased deformation would be prevented by the compression steel which usually has a large surplus of strength.

The conclusion as to the "continued yielding in the upper fibers" does not seem to be warranted, because even in the test the change in net deformation after 160 days was slight. The small differences may be attributed to other sources more than to yielding of the material. Even if the yielding continued it would rather increase stresses in steel than break the bond "from the center toward the supports."

Although the deflection continued to increase for a long time, it will be noticed that in no case was the maximum deflection excessive. In fact, it was not larger than would be expected by computations. For the beam 30 in. wide and 5½ in. deep the theoretical maximum deflection for a 12-ft. span is about ½ in. This agrees very closely with the actual deflection at 450 days. The stresses in steel, on the whole, were not any larger than would be expected from computations. The deformation of concrete was considerably larger than would be expected, but most of it did not produce any stresses because it was caused by shrinkage.

It is to be regretted that the specimens were not tested to destruction after the time tests were completed. This would have given some idea as to how much the so-called yielding affected the actual

strength of the specimens. It is very desirable that, with Mr. McMillan's tests as a basis, thorough investigations be made of the subject both under laboratory conditions and in buildings in actual service.

Erie Flood Capitalized to Discredit Coatesville Dam

WITH contracts let and construction started the new water-supply project for Coatesville, Pa., involving a concrete dam on Rock Run and a filtration plant, faces opposition which threatens to bring the work to a sudden halt. Coatesville, it will be recalled, is the town which, in February, 1912, was visited by a severe typhoid epidemic, due, according to findings of State Health Commission, to the use of polluted water which was characterized by Dr. Samuel G. Dixon as "unsafe for human consumption." The number of typhoid cases reported, more than 200, was sufficient to demonstrate the need for preventing a repetition of the water-borne epidemic and when the new dam and filter project was submitted to popular vote it was ratified by a substantial majority. Certain local interests, however, are now conducting a vigorous campaign against the much-needed improvement and an attempt has been made to have the Governor of Pennsylvania use his influence in securing the withdrawal of the permit for the work. The argument advanced is that the proposed dam will constitute a flood menace, and with the Erie disaster fresh in mind it is easy for the papers to make capital of this contention, notwithstanding the fact that the Erie catastrophe was due, not to the failure of a dam, but to the obstructions and encroachments of structures on the channel of Mill Creek. This point was made clear in the Engineering Record's account of the Erie flood published Aug. 14, page 186.

The Coatesville situation is of more than local interest for it involves methods of influencing public opinion, through the daily press, which tend to discredit the engineering profession in the eyes of the layman. It is not proposed here to discuss the relative merits of various water supply systems for Coatesville or to pass judgment upon the question of whether or not the work now under construction will curtail the supply of water drawn directly from several streams for use in the local steel mills. How potent this factor is in the opposition is beside the point. The matter of chief import to engineers is that the campaign to stampede public opinion is based upon propaganda declaring that dams are unsafe. True it is that dams have failed, but if the argument of the opponents to the Coatesville dam is sound it can be carried further. For example: Lives have been lost in railroad wrecks, therefore we should have no railroads; steamships have sunk, therefore prohibit marine traffic; buildings have collapsed, therefore live in canvas tents. The days of haphazard dam construction in Pennsylvania have passed and with the safeguards that now surround projects for impounding stream flow, involving submission of detail plans by

competent engineers and their approval by the State Water Supply Commission, dangers which have been magnified for partisan purposes cease to exist. It is an old story to find that dams which have failed have been built with little or no investigation of subsurface conditions by borings and without competent engineering supervision in the preparation of the designs or the conduct of the construction work.

Coatesville's case is different. The new water supply project has been designed by a consulting engineer of long and varied experience and the plans have received the approval of the State body constituted to pass upon the safety of such structures. The scareheads concerning the Rock Run dam, therefore, tend to create distrust in engineers and their work and are a form of attack which is nothing more or less than hitting below the belt.

The solution to Coatesville's case is not in the abandonment of its work for a pure water supply, but in the vigorous prosecution of a project for preventing another typhoid epidemic such as that of 1912, along a policy which, founded upon reliance on sound engineering advice, can not fail to be a decided benefit to the community.

Galveston's Sea-Wall the City's Salvation

AMID the chaos in the wake of the Galveston storm of Aug. 17 one structure stands out in bold relief, a monument to engineering skill and foresight—the sea-wall. Flanking the shore line of the island city this sturdy rampart of concrete and steel bore the brunt of the ocean's onslaught, and no higher praise can be bestowed upon it than to say that when called upon in an extreme emergency—one fully as great as the hurricane of 1900—it did its duty. Galveston's seawall was the city's salvation, and to the engineers who designed it and to the contractors who built it the Texas town owes a debt of gratitude which can never be adequately repaid. The damage done, of course, was severe, but there was no such toll in lives and property as was taken in 1900, and for this the seawall is responsible.

It takes a catastrophe like the Galveston storm to demonstrate to a public, often forgetful of those to whom it owes its safety, that the civil engineer is the foundation stone upon which the physical welfare of cities must be built. If the Galveston storm is instrumental in spreading this doctrine broadcast it will have done a lasting service. Cities elsewhere face dangers in the form of storms and floods, but disasters such as the most recent one at Erie, Pa., can be forestalled, in large measure, if the proper technical advice is secured well in advance and then acted upon. City officials throughout the country may well ponder over the Galveston lesson and take inventory of their own state of preparedness against unforeseen catastrophes which engineers can aid them in preventing.

To the yeoman work which the sea-wall performed must be added mention of the part played by the United States Weather

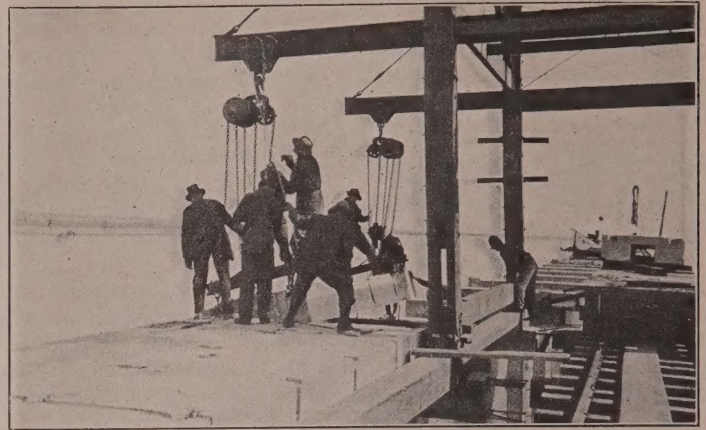
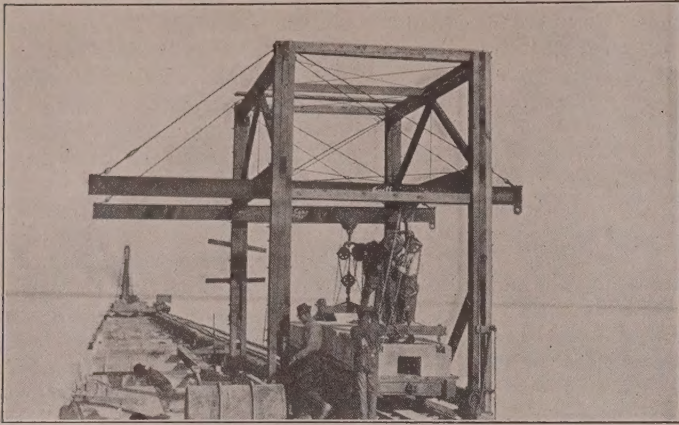
Bureau in preventing a greater loss of life than was actually recorded. Again science looms up as a protector in times of impending disaster. The hurricane which swept over the gulf was born in the region of Barbados and, gathering strength rapidly, started on its journey of destruction in a northwesterly direction across the Caribbean Sea and Gulf of Mexico. The Weather Bureau's observations foreshadowed a storm of unusual proportions and the news was flashed ahead to prepare for trouble. In fact, before the hurricane hit Galveston men were dispatched on motor cycles from the Weather Bureau's office, spreading the alarm so that people near the waterfront were able to reach places of safety. This move was certainly responsible for a great reduction in the loss of life.

Accurate reports as to the extent of the storm's damage are just beginning to arrive in the East. None of Galveston's substantial buildings was destroyed, although many frame structures along the waterfront were badly wrecked, and the brick boulevard back of the seawall was scoured out. The face of the seawall was curved and threw huge columns of water vertically into the air. The impact of the waves was thus broken but the hurricane, blowing at velocities as high as 90 miles an hour, swept the huge volumes of water, as they hung in mid-air, back over the wall, so that the city streets were flooded to depths of from 6 in. to 2 ft. There is an opportunity for profitable study in what might be termed a secondary line of defense along the waterfront—some provision for holding back water blown inland from the sea-wall.

The damage to the causeway which connects Galveston with the mainland is, apparently, the city's greatest loss. This causeway is a viaduct about two miles long, consisting of a series of concrete arches in the central section, flanked on either end by an earth embankment retained by reinforced-concrete sheet piling and with slopes protected by concrete slabs. The arches resisted the storm's fury but the north approach and about 1500 ft. of the south approach embankment were demolished, except for the concrete sheet piling and caps. Pier 10 was shattered and one grain elevator was badly wrecked. The other elevators and wharves sustained minor damages.

A serious condition was created by the breaking of the pipe line which carries the city water supply across the bay, but the broken section is being by-passed by a new 8-in. line laid on the causeway for service until the break can be repaired. For a time water for drinking and cooking purposes was distributed by wagons from the stored supply.

Galveston has passed through a trying time but it is clearing away the storm's debris and building anew with the same pluck which marked its activities after the hurricane in 1900. In such reconstruction as there is to be done engineers will play an important part. Their work has brought the city safely through a severe ordeal and they can be relied upon to contribute their share in the further development of the southern seaport.



PLACING UNIT CONCRETE FLOOR SLABS FROM THE TRAVELING GANTRY—SLABS WEIGH 5 AND 6 TONS EACH

Unit-Construction System Applied to a Three-Mile Concrete Viaduct to Reduce the Cost

California Highway Commission Develops Scheme for Bridging Yolo By-Pass near Sacramento Within Funds Allotted, About One-Third What the Usual Structure Would Have Involved

TO COMPLETE one of the main trunk lines of the California State highway system it was necessary to bridge the Yolo by-pass, a flood channel of the Sacramento River, near the city of Sacramento, with a structure 16,310 ft. long. Because of the rigid economy which it has been necessary to practice on the entire California highway system, it was considered that a concrete structure of this length must be of the cheapest possible design to come within the sum which could be consistently allotted to this part of the work. The highway engineer's office, therefore, undertook to work out such a design, which would still be up to State highway standard. The resulting design consists of 13,889 ft. of permanent, all-concrete trestle; 2280 ft. of wooden trestle on creosoted piles; and a movable span of 80 ft. clear length with its connections to the concrete trestle to be installed in the remaining 141 ft. The wooden trestle was used on a part of the structure which, while necessary under present conditions, it is expected can be replaced by fill at the end of its useful life, since it is outside of the levee line established in connection with the project for the control of the flood waters of the Sacramento River.

The cost of the concrete section was lowered materially, it is thought, by the method of construction adopted, which provided for casting the floor slabs as sep-

arate units in a casting yard at one end of the viaduct and then grouting them in place in the structure when properly seasoned. The contract was let July 21, 1914, for the concrete and timber trestle portion of the viaduct, to be built according to the highway engineer's plans, at a total cost of approximately \$393,000.

SCHEME OF CONSTRUCTION

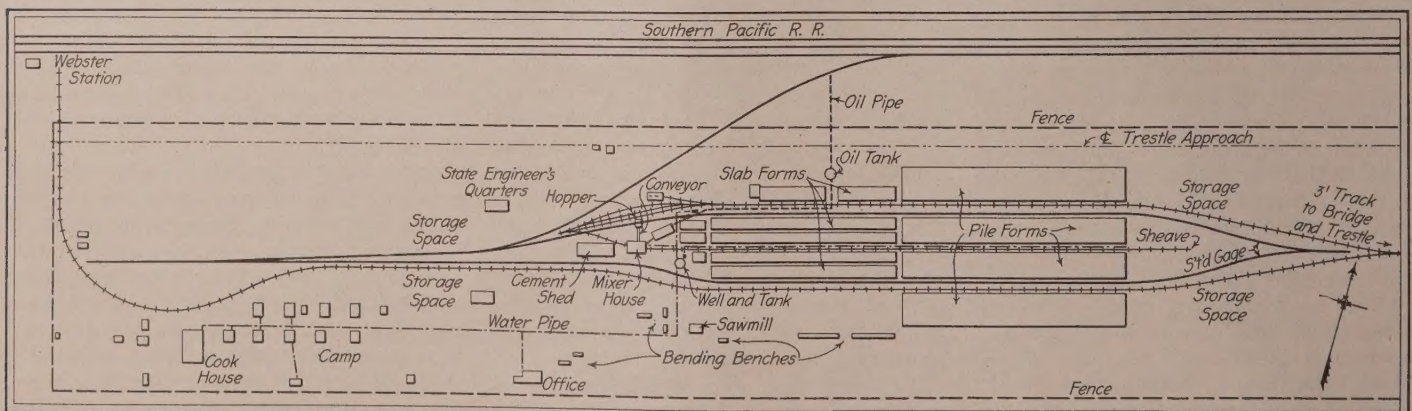
When work on the trestle was started last August the basin was dry and the pile driver was worked from 12 x 12-in. skids laid on the ground with 2 x 6-in. greasers on top of gunnels, backing away from the trestle as the work advanced. When the high water flooded the basin in February a temporary trestle was driven, from which the driver has since been operated. A small driver equipped with a drop hammer works ahead of the large driver, driving and capping the temporary trestle. The large driver, after moving back from a completed bent of the permanent structure, pulls up the temporary bent on which it worked, and caps and piles are floated ahead to the small driver for redriving. Temporary piles are placed 9½ ft. on centers with four piles to the bent, driven from 8 to 12 ft. in the ground, or enough to keep the caps clear of water.

In the all-concrete section of the viaduct each bent consists of two plumb and two

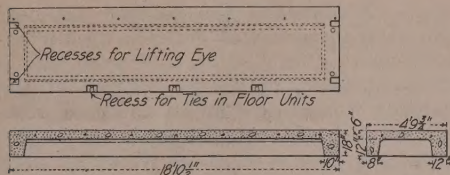
batter piles. The construction scheme was to drive all four piles in each bent before moving the driver, and to cast the monolithic concrete cap first on two piles of each bent, or over half the width of the structure. This made it possible to place temporary 8 x 12-in. wooden caps on the other two piles of each bent and thus provide support for a temporary track which would at all times be available for the delivery of materials, and whose extension depended only on the driving of the concrete piles. For the temporary stringers 12 x 12-in. timbers were used, lapped and drifted to the temporary caps. Ties and 48-lb. rails were then placed, the ties being nailed to the stringers with 8-in. spikes not driven quite home.

CASTING YARD

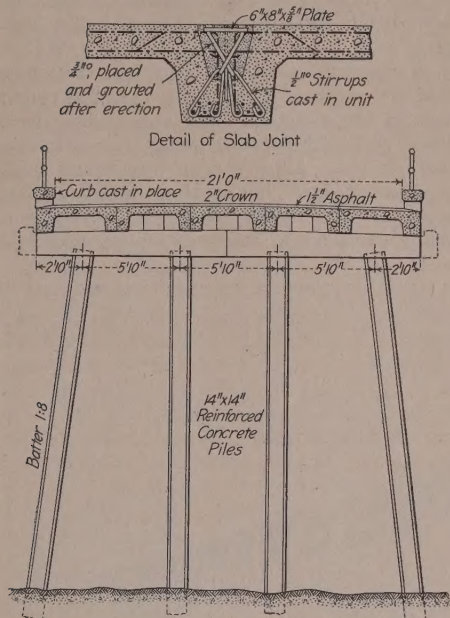
The concrete pile and floor slabs are cast in a yard laid out near one end of the trestle and adjacent to the tracks of the Southern Pacific Railroad. This location affords easy access to the yard for the delivery of materials and requires only a short haul to the work. Crushed rock and sand are delivered to the casting yard in standard bottom-dump cars which are switched by a locomotive crane over the hoppers in position for dumping. From the hoppers a chain bucket conveyor carries the material into bunkers over the mixer,



LAYOUT OF PLANT AND CAMP AT CASTING YARD, LOCATED ALONG RAILROAD NEAR ONE END OF CAUSEWAY



DETAILS OF SLABS



Section between Bents

DETAILS OF YOLO CONCRETE TREESTLE

whose capacities are 90 cu. yd. of sand and 180 cu. yd. of rock.

Mixing is done by a 1-yd. motor-operated batch mixer. From the mixer concrete is discharged directly into the bottom-dump buckets standing on flat cars operated by cable from a hoisting engine. From the cars the buckets are handled by the locomotive crane, which dumps the mix slowly into forms at the desired point and then swings the empty bucket back to the car. The average time between dumping successive buckets is two minutes, and it has

WEIGHT OF CONCRETE PILES		
Length, ft.	Volume, cu. yd.	Weight, tons
32	1.50	3.00
35	1.65	3.34
40	1.91	3.86
45	2.17	4.39
50	2.43	4.92

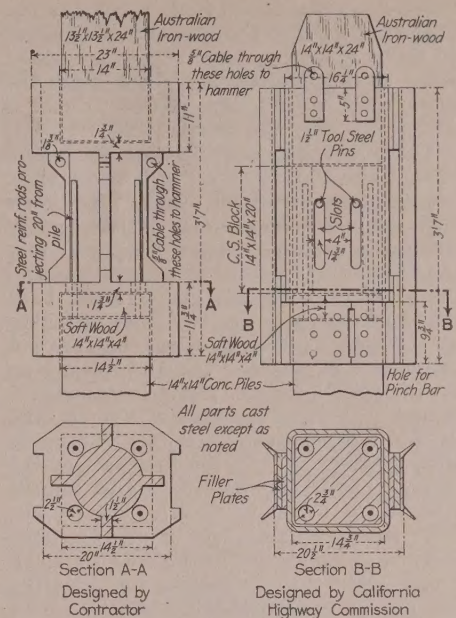
been found that a crew of seven men requires the full two minutes to spade the concrete properly in the forms. A five-sack batch of 1:2:4 mix is used. The mix is placed fairly wet, about 30 gal. of water being added to each batch when dry material is used. While in process of setting the concrete is wet down with a hose several times each day.

The concrete crew in the casting yard includes the following: Foreman, two men at mixer, one man in cement shed, engineer on hoisting engine, locomotive crane engineer, tag man, finisher and seven spaders. This crew usually pours, in an eight-hour shift, from 90 to 120 cu. yd. The concreting crews work from 5 p. m. to 1 a. m. daily, using carbide lights for lighting. The locomotive crane, which has a capacity of 25 tons on a radius of 12 ft., works three 8-hour shifts each day—from 8 a. m. to 5 p. m., loading floor units for the bridge; from 5 p. m. to 1 a. m., handling concrete in buckets, and from 1 a. m. to 8 a. m. taking cast units and piles from forms and placing in storage piles, etc.

In both slabs and piles the reinforcement is made up and placed in the forms as a unit. This work has been very accurately done, the inspectors report, and the cost has been comparatively low. The bending, assembling and placing in forms has amounted to about \$7.50 per ton of reinforcement, and at times has been as low as \$6.50 per ton. The weight and yardage of piles was found to average as shown in the above table.

HANDLING THE CONCRETE PILES

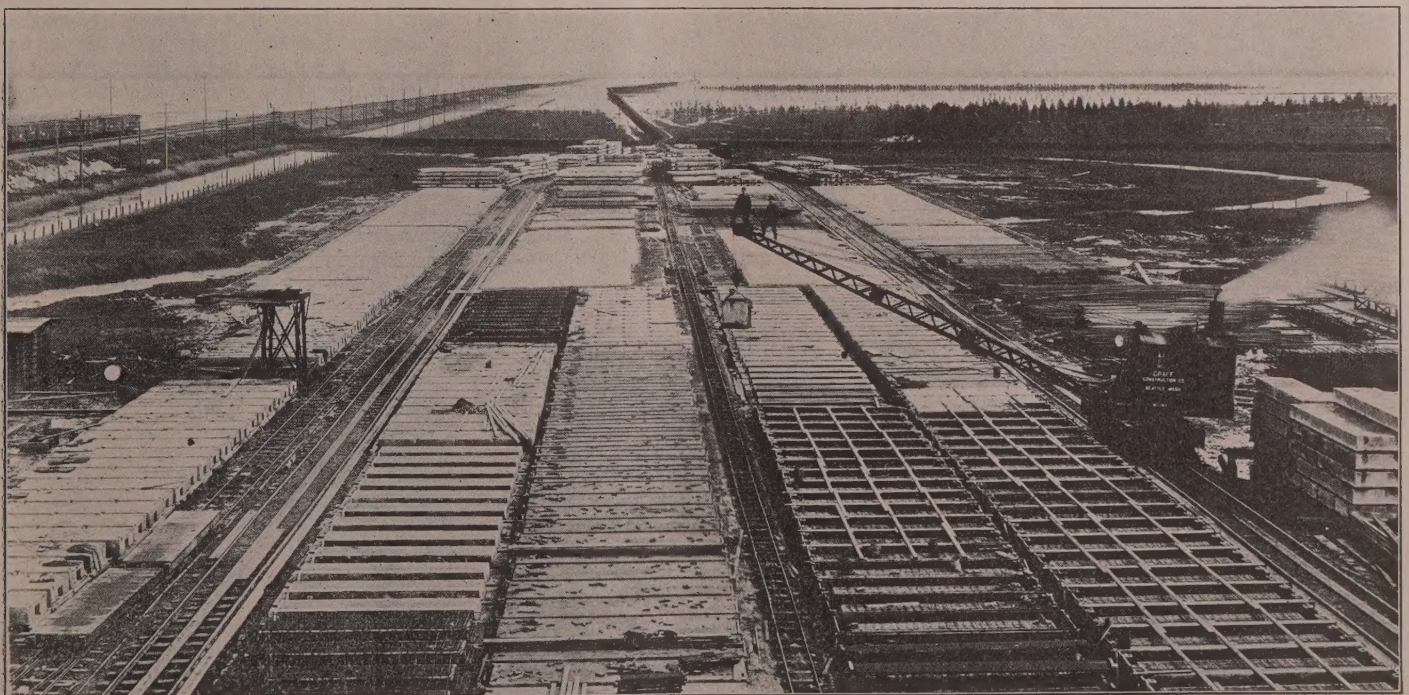
A total of 2932 concrete piles are required in the all-concrete section of the viaduct, of which 1084 are 35 ft. long, while the others range from 32 to 50 ft. in length. The longest piles to be driven are expected to have a penetration of about 30



PILE FOLLOWERS USED WITH SUCCESS

ft. The greatest penetration up to July 1 was 25 ft. The soil is a mixture of sand and clay and varies greatly in bearing power. In at least one instance a ledge of soapstone was encountered which prevented driving piles to grade. The piles are cut off by the hammer-and-chisel method, three men on a scaffold usually cutting two piles in an hour. The reinforcement is first cut with hack saws and the concrete is then split off with wedges.

From the casting yard out upon the viaduct the materials are delivered by one 5-ton gasoline motor which ordinarily works three eight-hour shifts, and two 7 1/2-ton steam dinkies, all 36-in. gage. The piles are hauled on standard trucks, five piles to a load. There is a single track from casting yard to viaduct over a temporary incline on a 4 per cent grade. The track on the viaduct is also a single line, but is provided with occasional sidings. Piles are hauled out by the dinky locomotives at night and lowered to two



LAYOUT OF CASTING YARD—METHODS OF CASTING UNITS—NOTE TREESTLE APPROACH IN BACKGROUND

"horses" so that the piles lie parallel to the viaduct center line and rest on the supports at about quarter points. They are eased down to this position by a line from the driver and a snub line passed around a driven pile near the ground line.

The pile driver is equipped with a 12 x 12-in. boom 48 ft. long set in the foot block between the permanent leads. Swinging leads are moved to one side out of the way when piles are to be delivered to the driver; the hammer line is used as a boom line, and the pile line as a fall line. It has been found necessary to use two lines in taking up the longer piles, but when they are not more than 35 ft. long they are picked up by the pile line from the driver fastened some 6 ft. back of the head of the pile, and in this manner are dragged to the driver without difficulty. In the first part of the work it proved as expensive to deliver the piles to the driver as to drive them. The labor cost per linear foot of pile averaged 8 cents, exclusive of fuel or crew on small driver, while that for hauling and lowering the piles averaged about 6 cents.

The penetration of the piles under the final blow varied considerably, in some cases being as much as 1/3 in., while in

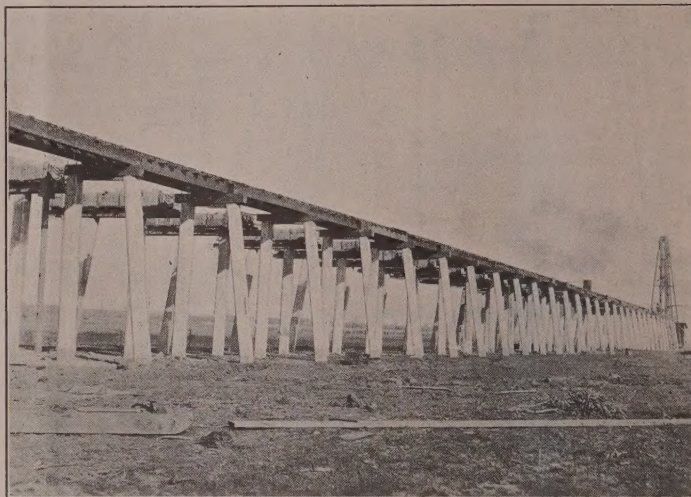
As the work advanced and the distance between the viaduct and the railroad grade became too great for accurate work, the piles were spotted by direct measurement and by transit on the center line of the completed structure. The distance is carried along the center line, and the measuring points for each day's work, usually seven or eight bents, are established on all four piles, right angles being turned by transit. The driver is first spotted for line, then pulled for distance, and the pile is picked up. As it is lowered to position it is plumbed with a 4-ft. mason's level. The hammer is then located and the pile struck several blows, after which the driver is pulled, if necessary, until the distance at cut-off is exact.

Two transitmen and a rodman are required for this work and the piles are

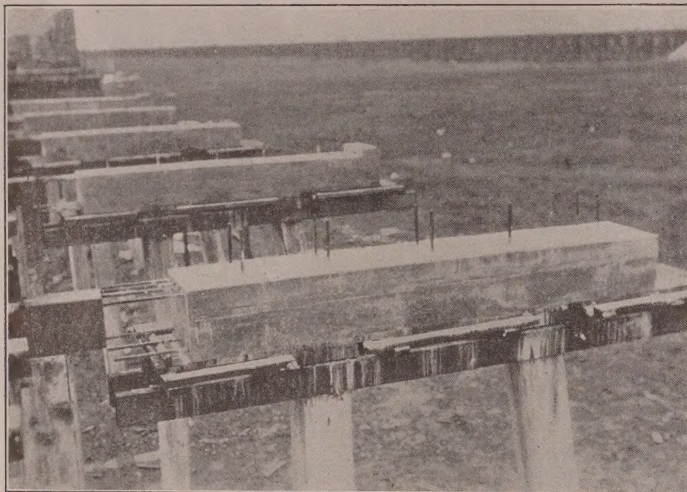
rods. A standard-type follower supplied for this purpose was entirely unsatisfactory, and a sand cushion head tried out by the contractor, in which the ram of the hammer struck directly on the sand resting on top of the pile, was equally destructive. The California Highway Commission meanwhile designed a follower especially for the purpose, of the type shown in the accompanying drawing. This has been used, it is reported, with great success.

It was anticipated in using this follower that the wooden block cushion would crush around the rods and jam. A sliding cast block was therefore designed to knock this cushion out. However, it was found that no matter how badly the block cushion crushed, the holes were seldom closed enough to prevent the rods of the next pile

RIGHT—TEMPORARY
CAPS AND TRACK



LEFT — CAPS ARE
CAST IN PLACE



others it was very slight, requiring twenty or even thirty blows to the inch. The average penetration for the final blow was from 1/6 to 1/4 in. The total time required to drive a 32-ft. pile with a penetration of 14 ft. was from 3 to 7 min. In one extreme case the contractor preferred driving a 45-ft. pile to grade rather than cutting it off. The pile was struck for 28 min. with a final penetration of twenty-five blows to the inch. Under approximately 1600 blows the pile head remained in perfect condition.

LOCATING THE PILES

To keep the bents at right angles to the viaduct and exactly 19 ft. apart a base line was first run approximately 200 ft. from the center line of the structure and parallel to it. The driver was pulled back until the transit on the base line could center the leads in position. A pile was then picked up, lowered and spudded to center as signaled by the transit man. After the pile was in position it was struck several times by the hammer and the driver was then pulled, if necessary, to center the pile at cut-off, after which the pile was driven without further moving of the driver. This base line was abandoned when the basin was flooded, a new base being then established on the Southern Pacific grade and the same general method being followed.

spotted in a remarkably short time, it is stated, frequently 30 or 35 piles being driven in eight hours. The standard of alignment allows a 2-in. variation in the head of the pile in cap, and a comparatively few piles have to be sprung slightly; as a rule, not more than from two to four piles in a day's work. When a pile is sprung it is pulled to place with a 1/2-in. cable fastened to the next pile at the ground line. A twister is used to tighten the cable, which is left on the pile until the cap is poured and floor units are placed and grouted.

SPECIAL FOLLOWERS

After some experimenting with various equipment for driving the concrete piles, an 8000-lb. hammer was selected which struck a 10,150-lb. blow 110 times per minute. With this hammer, however, the pile shattered considerably, due to the velocity of the blow, and very much better results were reported when a No. 1 Vulcan hammer was substituted. The latter weighs 5000 lb. and strikes a 17,500-lb. blow with a drop of 3 1/2 ft., averaging about fifty-six blows per minute.

The piles had to be driven with four 7/8-in. reinforced rods projecting 20 in. from the head, and it was at first difficult to prevent shattering of the head by any follower which would accommodate these

from entering. A 4-in. fir block was used as a cushion and could be used for six or eight piles, and in some cases many more, the maximum being twenty-six piles. After having been used for 488 piles this follower was discarded in favor of one which the contractor had made from cast steel as shown in the same drawing.

This cast-steel follower also worked very well, it is reported. It is equipped with a 14 x 14-in. block of Australian ironwood in a position between the follower proper and the ram of the hammer. This block, which is chamfered at the upper end and set with a heavy cast-steel cap, burns out after an average of about five days of driving, or more than 100 piles. It is believed that to prevent the head of the pile from shattering all lateral pressure should be kept from the projecting rods, and to accomplish this the followers were provided with 2 3/4-in. holes in the 4 x 14 x 14-in. blocks.

SLABS HANDLED BY GANTRY

The concrete caps are cast in place, monolithic with the heads of the concrete piles, only half the full length of each cap, as already mentioned, being cast at a time. When a considerable number of the bents have been thus capped and the caps sufficiently set, the longitudinal floor slabs are placed and grouted in place. These slabs, which are cast in the yard and delivered to the work ready for service, are in two sizes; those which are placed on the outer edge on either side of the roadway contain 3.08 cu. yd. and weigh 6 1/4 tons each, while the inner slabs each contain 2.59 cu. yd. and weigh 5 1/4 tons. Each 19-ft. bent is thus spanned by five concrete floor slabs,

two outer and three inner. Since only half the length of the concrete caps is poured at first, only two of the five floor slabs to each bent are placed before the track is shifted over from the temporary wooden caps to the completed section of the floor. Each of the floor slabs is provided with ring bolts embedded in the concrete at the four corners. The slab is picked up from its form in the casting yard by the locomotive crane and loaded on flat cars which are delivered in trains of two cars each to a gantry traveler spanning the full width of the trestle at the desired point.

The gantry traveler, which is shown in the illustrations on page 248, is supported on four posts, each resting on a timber dolly carried on two 12 x 12-in. timbers running from bent to bent. The traveler is moved along as desired with pinch bars. With the traveler at the desired position it is wedged and chained to prevent tipping and the cars containing slabs are spotted directly beneath it. The floor slab is then picked up by two 5-ton Yale chain blocks and lowered into position on the caps. The caps are previously wetted down and a mortar bed is placed. The weight of the unit squeezes the mortar out on all sides, showing uniform bedding. A maximum of sixty slabs has been placed in an eight-hour day with a setting crew of one foreman, a mason and five laborers. The average cost of setting and grouting joints computed after two weeks' work was 26 cents per ton. The cost of labor only in hauling from yard, including loading, was 11 cents per ton.

Expansion joints are made between slabs by using 16-gage galvanized-iron channels set in the concrete. Movement between units at the expansion joint is noticeable at the slightest rise in temperature, it is reported, but under the rise thus far experienced, from 40 deg. to 102 deg. Fahr., the action of the expansion joints has been perfect. The secret of success in this type of joint, it was pointed out, was in keeping the joints raked out as the slabs are bedded and afterward keeping them perfectly clean.

The work has been carried out according to designs prepared in the headquarters office of the California Highway Commission, R. E. Dodge, office engineer, being in charge of the design. B. G. Gerwick, resident engineer, is in immediate charge of the work in the field, under W. S. Caruthers, division engineer. The whole work is under the general direction of Austin B. Fletcher, highway engineer. The contract for the work is held by the Graff Construction Company of Seattle.

Panama Canal Handled 4,969,792 Tons During First Year

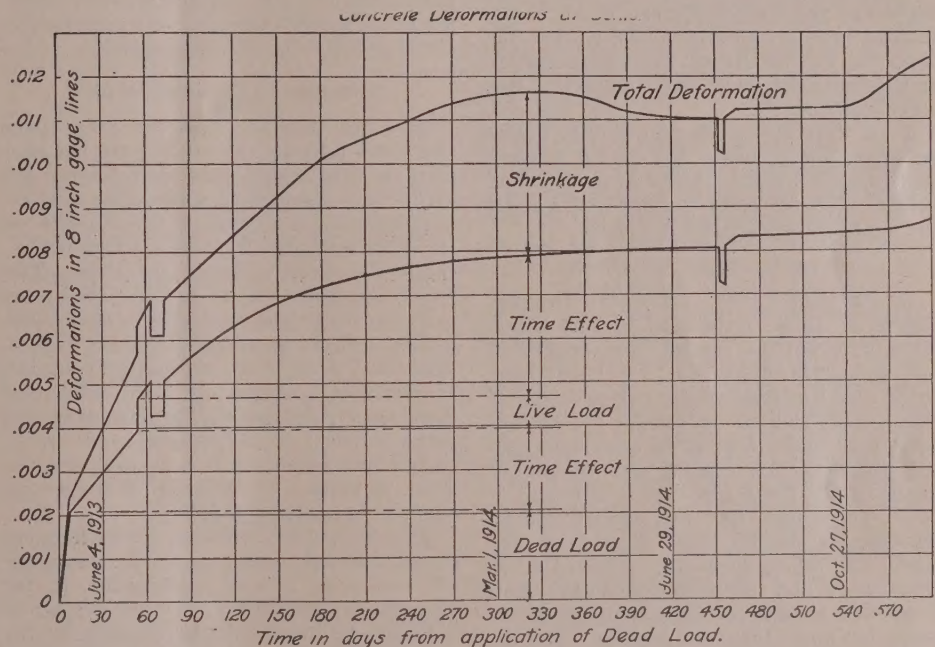
TRAFFIC for the first fiscal year of operation of the Panama Canal, ended June 30, but embracing only 10½ months, from Aug. 14, 1914, to Jan. 30, 1915, is reported in the Canal Record. During the period the canal was used by 1088 vessels, and 4,969,762 tons of cargo were moved. At this rate the movement would be 5,679,762 tons in a full calendar year, 473,313.4 tons per month or 15,530.6 tons per day. The movement was 2,125,735 tons eastbound and 2,844,057 westbound. The heaviest month was March, when 635,057 tons were moved. There were only 137 vessels moved that month, however, while in June 143 vessels carried only 603,180 tons. In May 142 vessels carried a still smaller tonnage.

Time and Shrinkage Affect Stresses and Deflections of Reinforced-Concrete Beams

Long-Continued Tests Made by F. R. McMillan Show Increase in Strains and Deflections—Compression Found in Tension Steel

THE effects of loads sustained for long periods of time have been made the subject of extensive study by F. R. McMillan, instructor in experimental engineering, University of Minnesota, who has just reported the results in a bulletin, "Studies in Engineering, No. 3," of that institution. The observation of progressive sagging and cracking led to the plans for scientific measurements of strains and deflection of beams and slabs, which have been carried on under laboratory conditions for the past nineteen months in one case and for shorter periods

round rods was tested by the application of the liveload to the one-third points. This beam was practically a 1 : 2 : 4 mixture of standard Portland cement, sand and limestone, and was poured in March, 1913; throughout the curing stage and period of test it was exposed to ordinary room temperatures from 60 to 80 deg. Fahr. Strain measurements were made by the Berry strain gage on 8-in. gage lengths located on the concrete at the top both near the center and just outside the load points. The gage lines on the underside of the beam were



CONCRETE DEFORMATIONS AT CENTER OF BEAM 30 IN. WIDE BY 5½ IN. DEEP

for several other specimens, the observations on which are to be continued in the future. The most striking features of the results given by the author are the continued yielding of beams and slabs and the possible presence in the longitudinal field of compression members of deformations from 5 to 15 times those to be expected from ordinary calculations. It is shown that the tensile steel in the lower side of loaded slabs is in compression under the action of shrinkage in concrete in the cases tested.

It is stated that the changes which take place are chargeable neither to poor construction nor to inadequate design, but rather to the nature of the material itself, its tendency to shrink and to yield under load. The large effects of shrinkage are emphasized, the shrinkage being obtained by measurements on gage lines made across the beams transversely, or around the edges of the slabs. The shrinkage strains are a relatively large proportion of the total strains. It is shown, as already given in an article in the Engineering Record of April 17, 1915, page 489, that the conditions of curing seemed to have relatively little effect on the final shrinkage.

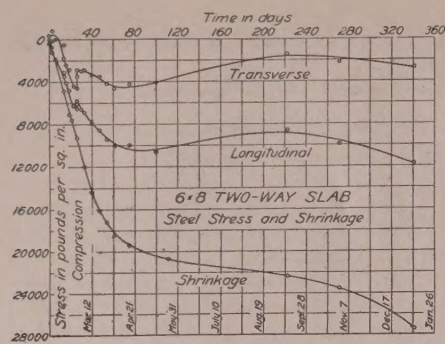
RESULTS OF BEAM TESTS

A beam 30 in. wide and 5½ in. deep of 12-ft. span reinforced by 10 plain ⅜-in.

drilled into the reinforcing rods and located similarly. Deflections were measured by a special apparatus using an Ames gage and measuring between small steel plates on the underside of the beam and on the floor vertically below.

The most striking feature of the results, as shown by diagrams, is the magnitude of the change that takes place with time. The total deformation has been separated into its three elements, the elastic deformation, the time effects and the shrinkage. One significant feature is the ready response of the concrete to changes in the moisture content of the surrounding air, even very slight changes being sufficient to cause either an actual swelling in the concrete or a noticeable reduction in the rate of shrinkage. The effect of shrinkage is found to be much less than that of the time effect in increasing deflection, because the latter acts on both top and bottom to produce increased deformation.

In obtaining the deflection, the effect of the supports was included, the net average deflection representing the difference between average total and average of the supports. The deflection curves show an increased rate near the end due to the increased rate of shrinkage from drying out caused by heating of the building in the fall. There is a possibility that this chang-



EQUIVALENT STEEL STRESSES—TWO-WAY SLAB

ing rate will continue from season to season, each subsequent swelling being followed by a period of increasing deflection, the total steadily increasing with time.

Computations for Poisson's ratio were made and the weighted mean of all observations gave a value of about 0.2 for the concrete, the results of the determination on the steel being much less satisfactory and quite variable.

Tests were also made on 4 x 5-in. beams on 42-in. spans, using a 1 : 2 : 4 mixture with pea-sized stone. The deformation and deflection curves cover the action for about one year, and show similar results.

RESULTS OF FLAT SLAB TESTS

In November, 1913, a 6 x 8-ft. two-way slab 3 in. thick, reinforced in both directions with 5/16-in. round bars hooked at both ends, was built of a 1 : 2½ : 4 mixture, using blue limestone of pea size and washed sand. This slab was cured for a period of ten weeks under a layer of sand kept continually wet. After being cleaned and allowed to dry for a few days a live load of 50 lb. per square foot was applied and an increase to 100 lb. three days later was made, the whole load was removed after eleven days, and reapplied twelve days later. From this time it has been continuously in place for more than ten months. The deformations and deflections were measured at the center of the slab and in both directions. The resulting continual increase in values is indicated by the diagrams. The shrinkage in this case was found to be relatively a much larger proportion of the totals than in any of the previous tests.

The rather remarkable condition that compressions of from 4000 to 12,000 lb. per square inch exist in the tensile steel of a loaded slab after nearly a year is noted. In view of the continued deflection it may seem unusual that this tensile steel should still show compression. That this is possible is claimed to be due to the fact that the slab is free to contract in all directions, which might not be the case in a series of continuous spans over a considerable area. In such a case shrinkage cracks would probably form, thus throwing on the steel the tension now being carried by the concrete.

The deflection at the end of eleven months is some 1000 per cent greater than that produced by the application of the full live load. It should be noted, however, that the absolute values of this deflection are quite small, the maximum deflection being only 1/40 in.

ONE-WAY SLAB TESTED

Similar results have been obtained on a 10 x 10-ft. one-way slab of a good grade of 1 : 2 : 4 machine-mixed concrete, which has been tested for about eight months. This slab is 4¾ in. thick and is reinforced with

¾-in. plain round bars of 5½ in. on centers longitudinally, and 5/16-in. rods 12 in. on centers transversely immediately above these. Measurements were begun when the slab was only twenty-four hours old. Deflection measurements were begun when the forms were removed at the age of 135 days.

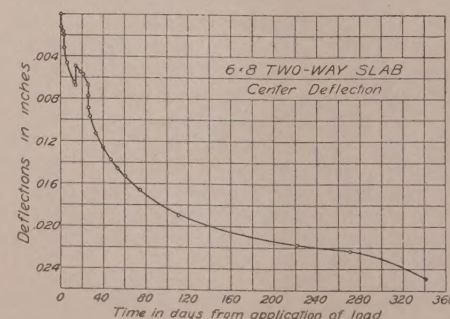
The curve of deformation for the concrete shows a continuous increase up to the time of application of the dead load, after a swelling for the first thirty days. A small sudden increase then occurs, which gradually grows greater with time, no added load being applied to the slab. The steel deformation indicates a shrinkage from the very first. A sudden drop in the steel deformation on the day the dead load was applied shows the elastic effect in the steel stress. The continued shrinkage in the next 125 days, however, carried this curve above its previous high point. It now shows a deformation of 0.00031 per inch, or a compressive stress of 9300 lb. per square inch.

SUMMARY AND CONCLUSIONS

In order to show that the progressive changes found by the author are not confined to laboratory slabs and beams, the results of some deflection measurements extending over a period of three years on three floor panels in a well-constructed reinforced-concrete building are given. Two panels so situated as to have received practically no load since casting show continuous deflection up to an average of about 0.35 in. The third panel was only partially loaded, as shown on a diagram, but the deflections were largely increased, the final deflection being nearly 1 in. Photographs of cracks in reinforced slab and in a position are also given as additional evidences of these time changes in existing buildings.

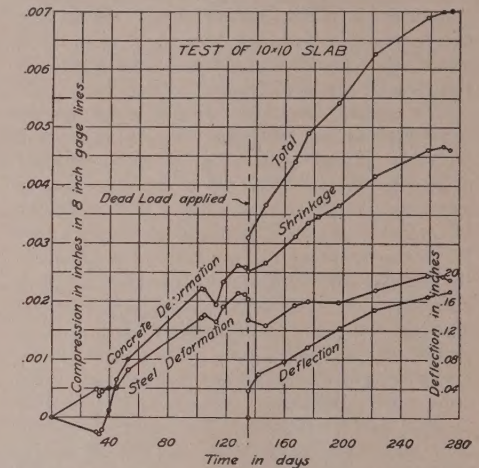
With regard to shrinkage, the author concludes that it is safe to predict a shrinkage of from ¾ to 1 in. or more in 100 ft. for concrete exposed to the ordinary dry air of a heated building. Slight changes in the moisture contents will retard the shrinkage or even cause a swelling. The yielding of the concrete under compressive stress with time, a phenomenon similar to the yielding of ductile metals when stressed beyond the yield point, is greater if the unit stress is greater and seems to go on indefinitely.

In these tests the deformation due to yielding was found to be from three to five times that produced immediately upon the application of the load. On the tension side of a beam or slab the effect of time is to cause a gradual increase in the steel stress from the breaking down of the concrete in tension or the failure of the bond. The combination of the extension at the bottom and a shortening at the top produces in beams and slabs a continually increasing deflection.



DEFLECTION OF TWO-WAY SLAB UNDER LOAD

Two possible effects, both of which might in certain instances be of serious consequence, are cited by the author as follows: First, the continued yielding in the upper fibers of a beam coupled with the gradual breaking down of the concrete in tension may result in a progressive destruction of the bond from the center toward the supports. Second, the possibility of high



RESULTS OBTAINED FOR ONE-WAY SLAB

stresses in the longitudinal steel of compression members. The time yielding of the concrete under stress combined with the excessive shortening due to shrinkage may result in deformations from five to fifteen times those expected from the ordinary calculations.

How Colorado Dam Construction Is Supervised

Failures Have Been Due to Inadequate Preliminary Investigations—State-Owned Automobiles Increase Inspectors' Efficiency

STATE RESERVOIR supervision in Colorado requires that specifications give the quantity of the material going into the construction, the expenses, the mechanical analysis of earth to be used in earth dams, the logs of test pits and borings, a report on the drainage area above the reservoir and an estimate of the maximum discharge at the dam site. These provisions and the following are outlined in the biennial report of the State engineer for 1913 and 1914. The removal of earth from the reservoir basin for the purpose of constructing dams has been almost always prohibited. The placing of the valves in the center of the dam has been preferred and the construction of wood and steel outlet pipes has been discouraged.

In the placing of riprap on the dam a substantial toe at the foot of the riprap has been insisted upon and almost always a base of gravel underneath both loose rock and concrete facings has been required. It has been necessary to return plans very often on account of both the inner and outer slopes being, in the opinion of the engineer, too steep. More adequate and a larger number of cut-off trenches underneath the dam have been insisted upon. The spillways have been required to be ample and of such a nature that they could not be obstructed. The placing of stop planks or other impediments in the spillway has been prohibited and the structure made as nearly "fool proof" as possible.

During the biennial period a number of failures have occurred in reservoir dams. These failures have been due almost without exception to inadequate investigation of the foundations of the dam and of the materials composing it.

In some cases, while the plans made ample provision for safety, the execution of the work by the contractors was of such a nature that the resulting structure was dangerous, and the engineer was impressed with the necessity in the future of having his own representative on the ground during the entire term of construction to see that the plans and specifications were complied with and to make necessary changes in the plans and specifications during the progress of the work, as the nature of the

Water-Soaked Bed of Blue Clay Caused Landslip at Cement Plant near Hudson

Wreck of Power House at Knickerbocker Portland Cement Company's Greenport Plant the Result of Unusual Subsurface Conditions

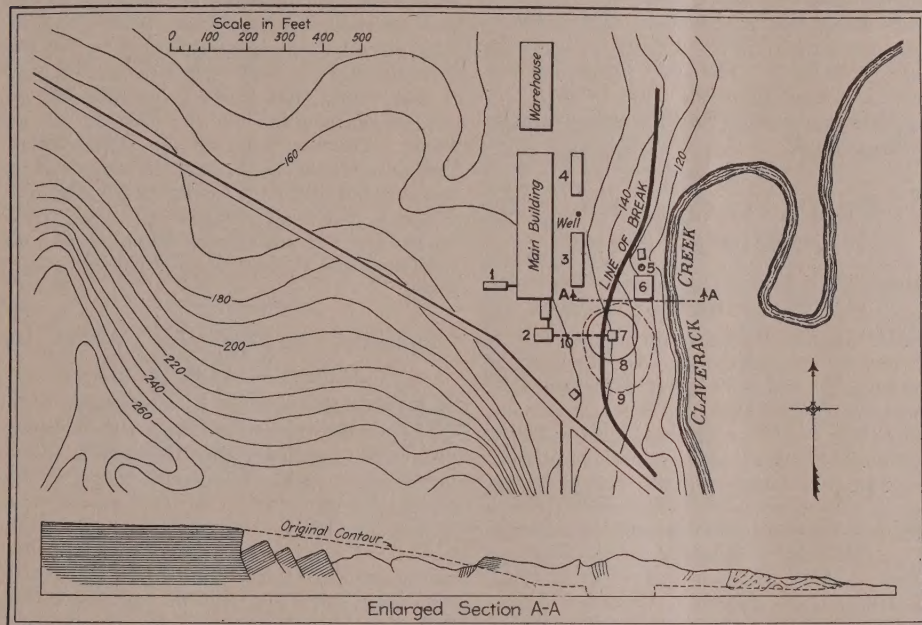
By D. H. NEWLAND

Assistant State Geologist, Albany, N. Y.

THE RECENT LANDSLIP on the property of the Knickerbocker Portland Cement Co., near Hudson, N. Y., described in the Engineering Record of Aug. 7, page 179, was attended by features that were quite extraordinary from the physical viewpoint and that have not been clearly or adequately set forth in the accounts

some coarse sand at the surface. The clays are 75 or 80 ft. thick as a maximum, becoming thinner toward the south and southwest where the buried rock surface rises up to join the slopes of Becraft Mountain, the limestone ridge from which the company derives its supply of rock for cement manufacture. The limestone apparently does not extend north of the highway on the map, the underlying rock on that side being the so-called Hudson River shale, which also underlines the limestone.

The slip involved a section that is now defined on the west by a vertical bank, up to 20 ft. high, which describes a broad curve opening toward the east, the center being about 225 ft. from the old creek channel. The ground between the bank and the creek as a whole shows subsidence, the vertical range of which does not exceed 20 or 25 ft. In some places within the area the level has changed only slightly, although even then the ground is usually tilted. The subsided area is divided into large blocks, which came down as units, bounded by fractures that follow more or less closely the direction of the limiting break on the west. The blocks on the western side are invariably tilted toward the bank, and are sometimes separated by open fissures 10 to 15 ft. deep. The appearance of the broken, disjointed area, with buildings shifted and upset from their foundations, trees inclined at all angles or prone upon the ground, and havoc everywhere, can hardly be conveyed in words.



SKETCH MAP OF REGION AFFECTED BY LANDSLIP NEAR HUDSON, N. Y.

Knickerbocker Portland Cement Company's plant consists of the main office, near road shown leading northwest toward Hudson, the main building and warehouse, and the smaller buildings, etc., numbered as follows: 1. Clay house; 2. Rock crusher; 3. Machine shop; 4. Coal house; 5. Chimney; 6. Power house; 7. Elevator; 8. Track of 65-ft. radius for electric crane; 9. Stone pile; 10. Underground conveyor.

materials encountered and other matters required.

AUTOMOBILES CUT EXPENSE COSTS

When the granting of railroad passes to irrigation officials was discontinued in 1913 the traveling expenses of the office increased beyond the available funds. Hiring automobiles and drivers as required was tried out at first, but this service, including team hire, cost about \$200 per month, and was found unsatisfactory as well as expensive. As an experiment the engineer purchased an automobile on his own account in 1914. The result was that the traveling expenses were cut about 33 per cent. The number of days the automobile was used very much increased, the mileage covered averaging about 100 per day, or 2500 miles per month, at a cost of about \$125 per month. Based on either a per diem or mileage charge, the cost was only about half what hiring the automobile would have been. If automobiles are provided it is the opinion of the engineer that five hydrographers instead of seven will be sufficient and that the amount of work accomplished will be increased. With such equipment the law relative to the examination of reservoirs each year can be easily complied with in connection with the hydrographic work.

previously published. In fact the occurrence finds little or no similarity with the ordinary earth and rock slides that take place on steep slopes, and so far as the writer can find has had but one counterpart in the rather long list of recorded slips in the clay terraces of the Hudson Valley. It was not caused by undermining through solution or erosion of the subsurface materials, by quicksands, or by caving of the bed rock, but was due without any doubt to a temporary condition of instability in the coherent surface stratum which at the time of the occurrence rested upon a thoroughly water-soaked mass of blue clay that under the load behaved practically as a fluid. It was this physical differentiation of the clay beds into a dryer, firmer, upper layer and a wet, mobile, underlying bed that supplies the clue to the peculiar nature of the slip and the attendant features.

GENERAL CONDITIONS AT SITE

Reference to the accompanying sketch map will assist in the explanation of the occurrence. It will be seen that the ground on which the plant is built is quite flat, except for the slight inclination toward Claverack Creek, which occupies a small trench in the clays about 40 ft. below the level of the base of the main buildings. The level ground is practically all clay with

CREEK BED RAISED

The subsidence when traced toward the creek gradually diminishes; at the creek itself are found the most remarkable features which help to explain the occurrence. A section of the creek bed about 600 ft. long has been raised vertically so that it now lies 20 ft. or more above its former level. The clay beds over which the water flowed may be seen to be standing on edge, having been upset in the movement, and some of the bed was shifted toward the east.

Along with the upheaval came an extrusion of the underlying blue clay which here found escape to the surface, flowing out in great masses upon the low ground to the east of the creek. The drag of this clay upon the surface stratum seems to have sufficed to overturn the latter. The blue clay when examined on the day following the slip was in a soft semi-liquid state, very greasy to the feel. In the flowage the bedded appearance which it exhibits when in place had been lost, the masses being without any definite physical structure.

CLAY FLOWED UNDER PRESSURE

Evidently the creek trench constituted a zone of weakness; it was the low spot in the area and also furnished the shortest path for the escape of the wet clay. The latter under the pressure from the higher ground on the west, and in a condition approaching fluidity, found partial compensation by upheaving the creek, which it did

so suddenly as to shed the waters in a flood and to leave fish high and dry on the bed.

With the rupture of the coherent surface clays a channel was opened for further relief of pressure by extrusion of the wet clay. Then came the subsidence which seems to have taken place block by block from east to west and to have continued without interruption until the present condition was attained. It seems to be quite clear that the trouble began at the creek and progressed to the west. According to some of the witnesses the ground rocked like an earthquake while the adjustment was in progress, a period of two or three minutes.

INITIAL CAUSE AND TEST BORINGS

The exact impulse that started the disturbance is difficult to find, if there were any single factor responsible. It seems probable that the wet condition of the clays, the lack of balance in the weight of the overlying surface stratum with the artificial load upon it, and the trench of the creek were all contributory to the accident, with the first as the most essential feature.

To establish the condition of the ground in the vicinity of the subsided area, a number of test borings were made which showed in fact that the blue clay at varying depths from the surface was thoroughly water-soaked. The water could hardly come from surface seepage alone; most of it probably is traceable to an underground flow from the north end of Becraft Mountain which admits the water along the edges of the clays as they overlap upon the rock slope. The few weeks preceding the occurrence were characterized by an extremely heavy rainfall, and the condition of the ground when tested was exceptionally wet.

LOADS ON FLUID LAYER

The main load upon the fluid layer was of course the overlying coherent stratum which had a thickness of from 15 to 30 ft. Its weight altogether greatly preponderated that of the artificial load represented by the buildings and the stock pile of crushed stone, which latter amounted to about 25,000 or 30,000 tons according to the most reliable estimate. The extent of the subsidence beyond the artificially weighted region appears to argue against the direct influence of the added load in disturbing the balance.

With the heavy rains in the month of July the wet zone in the lower clay must have raised considerably above the normal level for ordinary seasons, and the thickness of the overlying coherent layer correspondingly diminished. This of itself may have been the potent factor in upsetting the equilibrium. The rainfall also produced a flooded condition of the creek which at the time, no doubt, was cutting more or less into its bed.

PREVIOUS SLIP SIMILAR

A slip very similar to this occurred in March, 1908, near Stockport, a few miles north of Hudson. The displaced area in this case was part of a forested strip along a small ravine which drains into Stockport Creek. There were no buildings or other works within the area, and the disturbance was not connected with any artificial impulse, so far as could be established. A section of the bank of the ravine broke away along a nearly vertical fracture and dropped 40 ft., while the bottom of the

ravine was raised as a separate block, the adjacent edges of the two blocks being disjoined by an open fissure 15 ft. across at the top. The slip occurred right after the spring rains.

There is little doubt that such balanced adjustments have happened repeatedly in the Hudson River region, although they have not been recognized in their true character. From ordinary slides of earth they differ so markedly, however, as to deserve special attention both from an engineering and geological standpoint. It is peculiar of their occurrence that they take place suddenly, if not without previous warning, and that the condition leading up to the final disruption probably develops very gradually. The fact that the seat of trouble—the wet substratum—is concealed below many feet of firm and coherent material renders it doubly difficult to forestall their occurrence. The only safeguard for structures built upon the clays in such circumstances seems to be thorough drainage of the ground.

159-Pound Girder Rail for Philadelphia Streets

Adaptability of Type of Construction First Tested in Street Carrying Heavy Traffic

THE South Philadelphia improvement, now being carried out by the city of Philadelphia and the Pennsylvania and Baltimore & Ohio Railroads, involves, among other things, the laying of several miles of permanent track at grade in Delaware Avenue. In this connection the railroads and the city have worked out a design for a 159-lb. girder rail for general use in the city streets. Cross-sections of the rail and splices and of the approved form of track construction are shown.

Each joint is held with four 1 1/4-in. bolts,

passing through 1 7/16-in. holes in the rail web, 1 5/16-in. round holes in the inside splice, and 1 5/16 x 1 5/8-in. elliptical holes in the outside splices. The spacing of the four holes is 7 1/2, 5 1/2 and 7 1/2 in., and the splice bars are 26 in. long. Each bar has two slots and two holes for spikes. The rails are laid on four-hole tieplates 10 3/4 x 7 x 3/8 in., with a 3/8-in. shoulder on top and a 1/4-in. shoulder on the bottom. The ties are spaced 18 to a 33-ft. rail, and for each 33-ft. length the rails are connected with six tie rods, consisting of 2 3/4 x 3/8-in. forged bars threaded at the ends and held by a standard square nut each side of each rail web.

The adaptability of this type of rail for tracks laid and operated in a public street used intensively by all classes of vehicles was carefully considered before a conclusion was reached. A track was laid with this type of rail at the intersection of two of the most heavily traveled streets in the city, and it was found that there is no difficulty or any objectionable jolt in crossing at an angle. Teamsters using the street longitudinally frequently drive with one wheel on the rail and find no difficulty in turning out. Wagons with all widths of tires, both loaded and unloaded, were driven on and off the track and there was no objection in any case.

Cincinnati to Sell All Water by Meter in Four Years

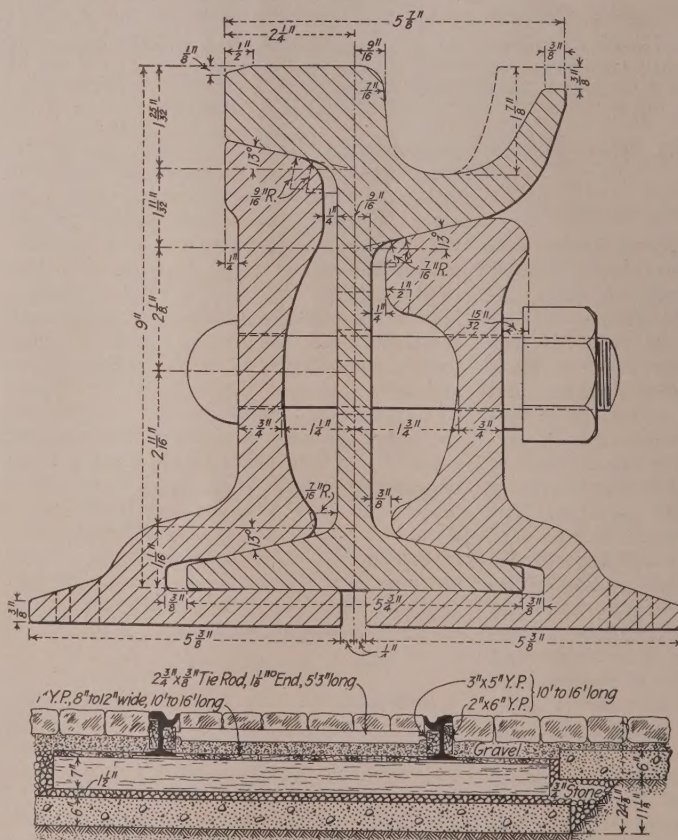
METERED service in Cincinnati is so satisfactory to the water department and to the consumer that Dawson J. Blackmore, administration superintendent, in his annual report to J. A. Hiller, superintendent, states that compulsory installation has been found both advantageous and necessary. At the present rate of installation every service should be metered within the next four years.

Tests were carried out on 8071 meters, and repairs made on 1872 meters in 1914. The average charges for repairs, including the test charges, were \$2.22 1/2 for 5/8-in. meters, \$2.60 1/2 for 3/4-in. meters and \$2.74 1/3 for 1-in. meters.

Watermetered in 1914 amounted to 45.9 per cent of that pumped. During the year 4828 meters were added, increasing the total to 35,201. This number is 61.1 per cent of the number of services. Consumers using metered water furnish 72.3 per cent of the revenue.

The average daily consumption was 125.2 gal. to each one of the 406,000 estimated persons served. In 1913 it was 125.6 gal., in 1912, 131.3 gal., and in 1911, 125.6 gal.

The cost of supplying 1,000,000 gal. was \$28.40 on ordinary expenses or \$66.83 adding interest and sinking-fund charges.



MAIN DIMENSIONS OF 159-LB. GIRDER RAIL, AND CROSS-SECTION OF TRACK IN STREET

New York Subway Tapped for New Connections While Carrying Heavy Traffic

Arched Concrete Tunnel Lining Cut Into to Join Lexington Avenue Line with Existing Tubes at Forty-Second Street

WHILE a million passengers are being carried every day through the New York subway under Park Avenue below the Grand Central Station, a connection between the existing tubes and the new Lexington Avenue line, involving the removal of the arched lining of the old tunnels where the new tracks cut into them from the sides, is proceeding without interrupting traffic. Instead of removing the whole arch roof, which is under a constant and heavy external load, only that half of the arch on

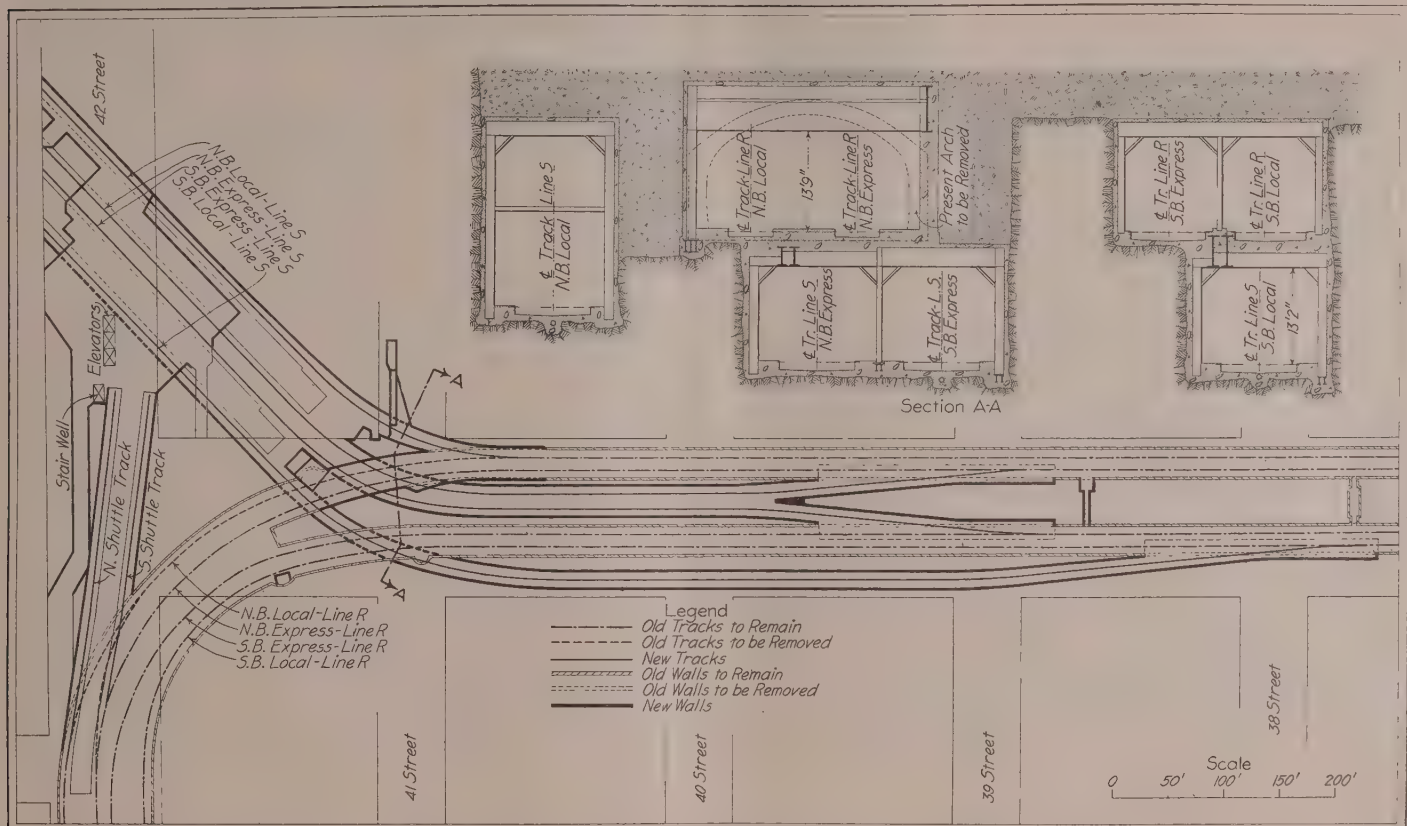
a point where it can be connected with the present tracks under Forty-second Street after operation on the Lexington Avenue line is begun.

The contract on route 43 extends through the Grand Union lot and down to Thirty-eighth Street on Park Avenue, where the southbound local cuts into the present tubes.

GENERAL PLAN OF CONNECTIONS

As will be seen from the accompanying drawings, the northbound local track enters

At this section, which is entirely cut out, and at other points where the old tunnel is broken into, angle-iron ribs bent to the shape of the tunnels and lagged with wood plank were placed inside the old tubes to enclose the tracks and safeguard operation while the old concrete is being removed. This lining was made flat on top to give room for setting the new steel. It was placed at night, during the hours when express traffic is suspended and local trains run on 7-min. headway. The old concrete is drilled in blocks about 2 x 3 ft., and split off with plugs and feathers. A wire rope is passed around each block, on which a small hoist, mounted under the decking, takes a strain before the block is broken loose, to prevent its falling on the temporary tunnel lining. The first block, at the crown of the arch, taken out in each 2-ft.



DIFFICULT CONSTRUCTION OF NEW LAYOUT CARRIED ON WHILE FOUR TRACKS (R) HANDLE 1,000,000 PASSENGERS DAILY

the side where the new tracks enter is being taken out. The thrust from the other half of this arch, which remains in place, is transmitted to the rock flanking the new cut by horizontal roofbeams bridging the new track and the old one into which it turns. The work also includes tunneling beneath the present tubes for two express tracks and one local track, and replacing the existing subway floor at these points by new steel work. Another feature is a very deep rock cut in the Grand Union lot, from the bottom of which the street decking on Park Avenue is supported on "stilts." This decking is unusual, in that it consists of timbers and plank floorings supported on latticed girders taken from elevated lines being rebuilt in the city.

The work at this point includes two contracts, known as section 1 of route 43, and section 1 of route 26. Both are being carried on by the same contractor as one job, though the contract on route 26 is for constructing the Steinway tunnel on the lower level from the present temporary station to

the east side of the present northbound tunnel on a rising grade. The present northbound tunnel, which carries both express and local tracks, is separated by a wide space from the present tunnel carrying the two southbound tracks. The future express, or center, tracks dip under the existing northbound tunnel and come up in this space on a rising grade. When they reach the level of the present tracks they break right and left into the old tunnels and connect with the existing express tracks. The southbound local track passes under both existing tunnels, turns down Park Avenue and penetrates the west side of the old southbound tunnel at Thirty-eighth Street. Here, and where the new express tracks break into the old tunnels, are the points at which only half of each old roof arch is removed. At the junction of the old and new northbound local tracks the load has been taken off the old tubes by decking the street, and the old concrete will be entirely removed and replaced with new construction.

wide ring has to be broken out with bull points, after which the concrete can be broken off in large chunks.

CONNECTING NORTHBOUND LOCAL TRACK

The floor under the northbound local track will be cut out and the track supported on trestles, through which the new track will be laid on a rising grade to within one rail-length of its connection with the old track. When all is ready for diverting traffic up Lexington Avenue the old track and the trestles under it can be removed by a large crew in a few minutes, and the last two rails, cut to the right length beforehand, inserted.

NEW METHODS USED FOR CUTTING INTO OLD ROOF ARCH

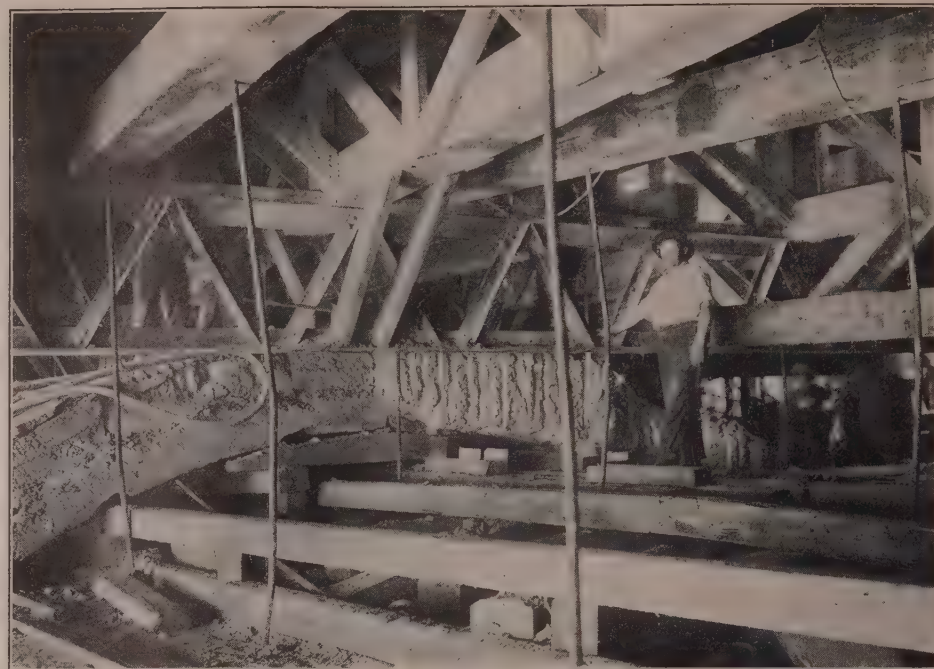
Where the express and southbound local tracks come into the old tubes there is a thick cover of rock over the construction which prevented decking the street and taking the load off the old subway tubes. The first step after the arch is exposed is

to cut into the old roof arch of the subway at 6-ft. intervals, removing strips of roof in which two beams can be set. These are placed in each niche and wedged up to transmit thrust from the remaining half of the old arch to the rock behind. The alternate strips of the old arch left between these niches are then removed, and more beams inserted in these spaces. Meanwhile, the conduits for the old subway, which were located in a trench under the center of each tunnel, are removed and replaced at the side of this structure, the trench left being filled with concrete. On this concrete are set steel columns, one under each new roof beam. These columns are, of course, set at night, while express trains are not running. The side wall next to the new tunnel is removed as fast as the roof beams are set, and the new roof concreted.

Where the new express tracks rise between the old tubes the rock has been removed until the sides of the old lining were exposed. It has not been necessary to shore the old tunnels at the spring-line of their arches, as the rock on the haunches of these arches has held them until the new roof steel was in place. The new express tracks are separated by a concrete wall, with embedded steel columns. This wall is being placed in advance of the new roof.

TALL SUPPORTS FOR STREET DECKING

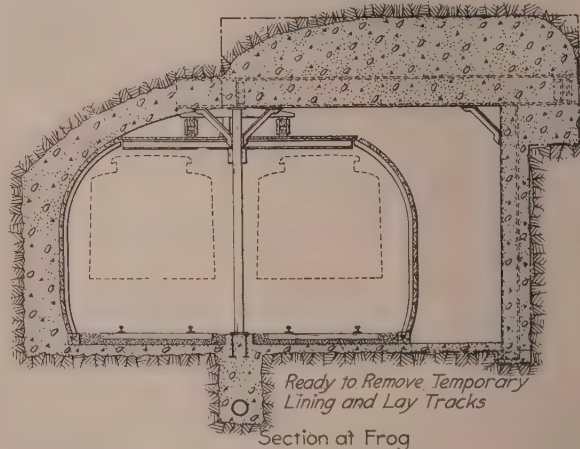
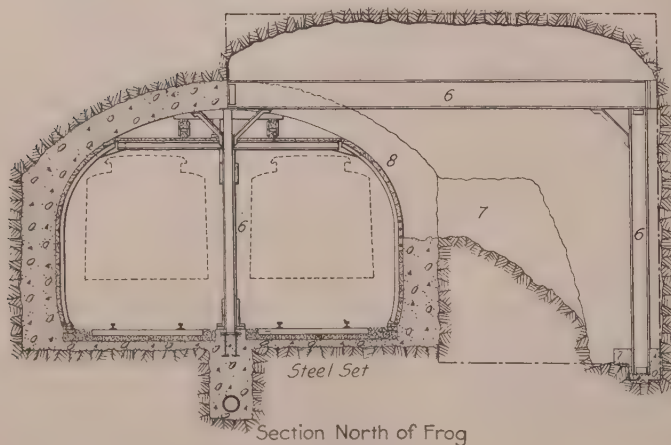
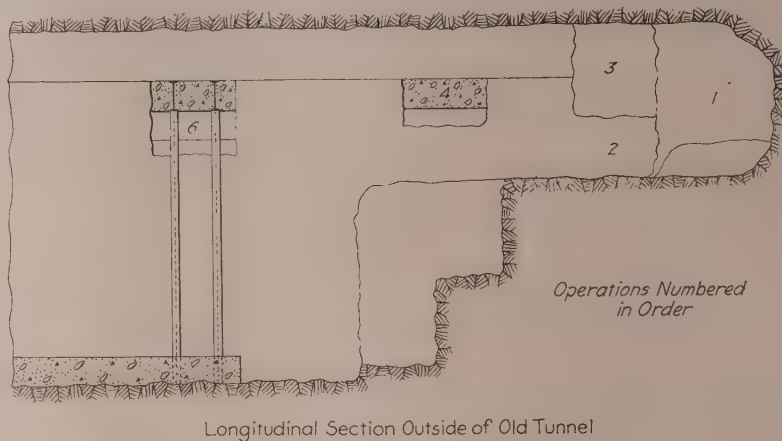
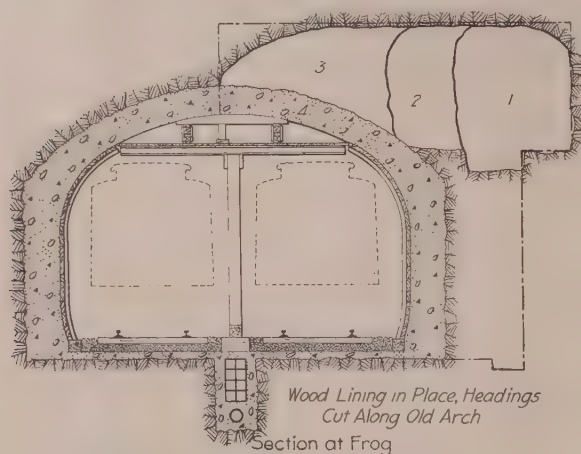
The four Lexington Avenue tracks cross under Forty-second Street over the Steinway tunnel, but below the level of the present tubes, which are themselves well below the street at this point. The rock excavation on the site of the old Grand Union building was, therefore, carried to 35 ft. below street level. The end of Park Avenue next to Forty-second Street was decked



CUTTING OUT OLD ROOF ARCH UNDER WIDE-SPAN STREET DECKING

where the northbound local turnout occurs, the decking being supported on transverse latticed girders taken from rebuilt elevated lines. The ends of these girders next the lot rest on unusually tall posts made of two 12 x 12-in. timbers bolted together. Each timber is butt-spliced, breaking joints with the other timber in the post, and no scabs are used. When the cut is extended under Forty-second Street, the decking on that street will be similarly supported.

With one exception all muck for the two sections is handled by derricks, and either dumped directly into wagons or into bins from which wagons are loaded. The exception is the elevator shaft north of Forty-second Street at the East River, up which muck is brought in tunnel cars from the lower end of the Steinway section. A derrick at the Forty-second Street corner of the Grand Union lot hoists muck from a shaft which serves the upper end of the



OLD ARCH TUNNELS REPLACED BY NEW CONSTRUCTION AT TURNOUTS WITHOUT ENDANGERING PRESENT TRAFFIC

Steinway section, and this derrick also covers part of the lot. Two other derricks on the east side of the cut through the Grand Union lot handle excavation from the cut and from the drifts under the present subway. These drifts are served by small cars carrying skips. These cars are pulled on narrow-gage tracks by small hoisting engines in the lot and near tunnel headings.

The mixer plant that will be used for this section is set under the east sidewalk on Park Avenue, near Forty-second Street, and is fed by gravity from the street. It is now being used to line the upper end of the Steinway section, by spouting concrete down the shaft referred to. A tower spouting system will be used for the work in the Grand Union lot.

A shaft and derrick at Fortieth Street take care of the express track tunnel between the old tubes, while the southbound local tunnel will have to be driven entirely

sion for the First District, of which Alfred Craven is chief engineer and Robert Ridgway, engineer of subway construction. It is part of the work under the second division, of which John F. Meyers is division engineer. The design of the connection was made under the direction of Sverre Dahm, principal assistant engineer, and Charles E. Conover, designing engineer of the commission.

Costs of Electric Pumping for Irrigation Tabulated

South Side Unit of Minidoka Project of U. S. Reclamation Service Uses Electricity at Cost on Largest Pumping Scheme

INASMUCH as success in irrigation projects depends directly upon annual cost of operation and maintenance as well as on original construction cost, figures

some water is taken for use on lands at that level. The resulting power necessary is about equal to that required to lift all of the water an average height of from 66 to 69 ft. Electricity supplied from a power plant utilizing a 46-ft. fall in the Snake River at Minidoka dam is transmitted about 11 miles to the pumping stations over 33,000-volt transmission lines. Power house and transmission lines are operated as part of the project and energy is supplied to the pumping station at cost. In winter a large amount of energy not then needed for irrigation is used in the towns for heating stores and houses, and the sale of this energy tends largely to reduce the charges that are placed against the pumping load.

On the Minidoka project depreciation has not been collected, and interest is not included, because no interest is charged on the money invested. It can readily be calculated by applying to the investment of



LATTICE GIRDERS SUPPORT PARK AVENUE—LEFT HEADING IS FOR EXPRESS TRACKS, RIGHT IS FOR WEST LOCAL TRACK

from the lot. Concrete for the express tunnel is mixed at the Fortieth Street shaft, and spouted down it.

AIR FROM TEN-YEAR-OLD PLANT

The old plant that supplied air for the Steinway tunnels, which is located above Forty-second Street on the East River, is being used to supply the drills on both these contracts and also for the subway section north of Forty-second Street on Lexington Avenue. The supply is carried through Forty-first Street underground in a 10-in. air main under 100 lb. pressure. The pressure lost in transmission does not exceed 1 to 2 lb. The plant contains two steam-driven compressors, one of 4500 ft. and one of 5000-ft. capacity, both run condensing, and an 1100-ft. electric compressor, as reserve. The steam is furnished by four water-tube boilers aggregating about 1000 hp.

The Rapid Transit Subway Construction Company, of which George H. Pegram is chief engineer, and Robert A. Shailer tunnel engineer, is contractor for these sections. The work is being done under the supervision of the Public Service Commis-

sion which give some idea of such costs are of value, even though these annual costs depend upon many factors. When the water must be pumped the number of these factors is much increased, the principal among them being cost of power, height of lift and size and type of pumping plant. Some figures showing the cost of pumping on the largest pumping scheme yet undertaken—that of the U. S. Reclamation Service known as the South Side Unit of the Minidoka project—may prove of value. Data furnished by Barry Dibble, electrical engineer in charge, from a paper prepared for the Idaho Society of Engineers, are here given in part.

The water is raised by large pumping stations up three 30-ft. steps; at each level

\$1,000,000 in the South Side Unit any rate of interest desired. About one-half of this cost is in the pumping stations and the other in the proportionate cost of power house and transmission lines.

TABLES OF COSTS

Table 1 gives the annual cost at the power house, which has a rating of 10,000 hp., for each year from 1910 to 1914. Although more than 30,000,000 kw.-hr. was generated in 1914, less than 25,000,000 kw.-hr. was accounted for in useful service; the rest was lost in transmission lines and transformers. The transmission lines now form a system of about 65 miles, on which two linemen do most of the work. The total power-house cost per kilowatt-hour deliv-

TABLE 1—POWER HOUSE—OPERATION, MAINTENANCE AND DEPRECIATION CHARGES

Year	Kilowatt-Hours Generated	Gross Cost		Per Kilowatt-hour Generated		
		Operation and Maintenance	Depreciation	Total	Operation and Maintenance	Depreciation
1910	10,000,000	\$8,949.00	\$8,805.00	\$17,754.00	\$0.00090	\$0.00088
1911	18,202,000	10,156.00	12,856.00	23,012.00	0.00055	0.00072
1912	20,092,800	12,613.00	14,057.00	26,669.00	0.00063	0.00070
1913	25,661,420	16,028.00	14,100.00	30,128.00	0.00062	0.00055
1914	30,069,993	15,191.00	14,615.00	29,806.00	0.00051	0.00048

ered at the South Side pumping stations is \$0.0014, of which \$0.0012 is power-house cost and \$0.0002 is transmission cost.

The gross cost of the peak load of 6300 kw. in 1914 was \$2.88 per horsepower. If interest on the investment in power-plant and transmission lines (\$500,000) at 6 per cent be added, it would increase the cost by \$3.58 per horsepower, making a total of \$6.46 per horsepower of peak demand.

Since 1910 the amount of land irrigated and water pumped has very greatly increased. Table 2, however, shows that the cost of operation and maintenance has not materially changed, although the depreciation item has increased with the addition of new machinery. For ready comparison with other plants the unit of cost has been taken as an acre-foot lifted a height of 1 ft., designated as a "foot-acre-foot."

TABLE 2—SOUTH SIDE PUMPING STATIONS—OPERATION, MAINTENANCE AND DEPRECIATION CHARGES

Year	Acre-Feet	Average Lift, Feet	"Foot-Acre-Feet"	Gross Cost		Cost per "Foot-Acre-Foot"		
				Operation and Maintenance	Depreciation	Operation and Maintenance	Depreciation	Total
1910	69,900	65.7	4,582,430	11,404	10,226	\$0.00250	\$0.00223	\$0.00473
1911	98,200	65.6	6,441,920	10,668	13,955	0.00165	0.00220	0.00385
1912	99,500	66.0	6,567,000	14,349	17,400	0.00226	0.00265	0.00491
1913	118,688	68.0	8,070,984	12,494	17,428	0.00155	0.00216	0.00371
1914	147,212	69.2	10,187,070	14,239	17,993	0.00140	0.00177	0.00317

In order to obtain the amount by which the running costs of this project are increased because pumping is necessary, all the items due to this feature, using the year 1914, have been combined in Table 3.

TABLE 3—EFFECT OF PUMPING ON RUNNING COSTS

Item	Operation and Maintenance	Depreciation	Total
Power house	\$10,570.00	\$10,169.00	\$20,739.00
Transmission lines	1,103.00	2,372.00	3,475.00
Pumping stations	14,239.00	17,993.00	32,232.00
Total	\$25,912.00	\$30,534.00	\$56,446.00
Cost per foot-acre-foot	\$0.00254	\$0.00300	\$0.00554
Cost per acre-foot	0.176	0.207	0.383
Cost per acre in project (48,000)	0.54	0.636	1.176
Cost per acre irrigated (35,788)	0.725	0.854	1.579

The annual cost of operating and maintaining the canals and laterals carrying the water for the land amounts to about \$0.75 per acre of irrigable land in the project. About 12,000 acres included in the project were not irrigated last year, but it is not thought that they will materially affect the costs. In general, however, it is to be expected that the cost of pumping will be greater per acre-foot with smaller plants.

WATERWORKS BOILER-ROOM EFFICIENCIES IN ST. LOUIS are promoted by a system of posting in the boiler houses the amount of coal consumed and water evaporated during each watch of eight hours, and of posting each week in each station the plant efficiencies of the various stations. E. E. Wall, water commissioner, states in his annual report that the method has resulted in a marked improvement in plant conditions throughout the water division. The engineers take hourly readings of the percentage of carbon dioxide in the flue gases, which at once gives them absolute information as to combustion conditions in the furnaces, and enables them to regulate the firing in closer accordance with the steam consumption. That the city profited is shown by the 14.2-per cent reduction in coal consumption over the previous year.

Elastic Curve Applied to the Design of the Sciotoville Bridge

Influence Lines Aid in Simplifying the Analysis of 1550-Foot Continuous Truss Spans—Exact Method Compared with Approximate

By D. B. STEINMAN

Special Assistant to Gustav Lindenthal, Consulting Engineer

BRIDGE engineers have been more or less familiar with the decisive advantages of indeterminate systems of construction, but only in recent years has there been a tendency in this country toward the adoption of such structures and, with it, a greater familiarity with the methods of designing them. One of the cardinal features in the newer methods of designing indeterminate structures is the application of the

is statically indeterminate in the first degree, as there are only two equations of condition, $\sum V = 0$, $\sum M = 0$, for the determination of the three reactions. One of the reactions, X , must therefore be determined from the relations governing the elastic deformations of the structure. For this purpose, a unit load ($X = 1$) is considered substituted for the desired reaction and the resulting curve of deformation determined, Fig. 3. As this deflection curve is independent of the actual loading to which the structure may be subjected, but depends only upon the elastic relations within the structure, it is appropriately named the "elastic curve."

The elastic curve has a three-fold significance. By its construction, it is primarily a deflection diagram, i.e., the ordinates of the curve represent the deflections at the respective panel points produced by a unit load applied at A . Applying Maxwell's principle, the same values must also represent the deflections at A produced by a unit load applied at the respective panel points. In other words, the elastic curve is an influence line for deflections at A . As the end A is constrained, however, these indicated deflections cannot actually take place. Instead the reaction X is evoked to resist these deflections, so that, finally, the elastic curve is an influence line for the reaction X .

CONSTRUCTION OF THE ELASTIC CURVE

To construct the elastic curve we consider a unit load applied at A and proceed to find the deflections at the various panel points of the structure. This may be done graphically, using a force polygon to get the stresses in the members and then combining the resulting strains in a Williot displacement diagram to get the deflections. An analytical procedure, however, proves more expeditious. For this purpose we apply the principle that the deflection curve for any structure is identical with the moment diagram obtained by applying the angle-changes w as "elastic weights" at the respective panel points of the structure. This exceedingly useful principle may be simply demonstrated as follows:

At any point P of a span AB , Fig. 4, assume an angle change or rotation of $\Delta\phi$. The straight line AB will then deflect to the position ACB , with the deflection angle $ACD = \Delta\phi$. If $\Delta\phi$ is measured in radians, we have $AD = a \cdot \Delta\phi$. The vertical deflection d at any section x is then given by the simple proportion

$$d:AD = x:l$$

Hence

$$d = \frac{AD \cdot x}{l} = \frac{a \cdot \Delta\phi \cdot x}{l} \quad (a)$$

Next assume a weight w applied at the point P of the span AB . The resulting moment diagram will be a triangle ACB . The bending moment at any section x will be

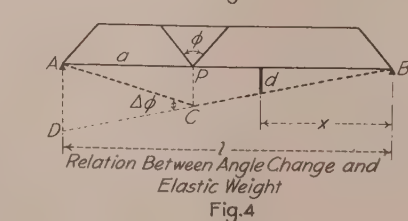
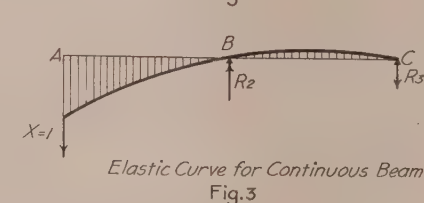
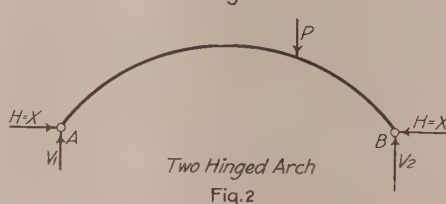
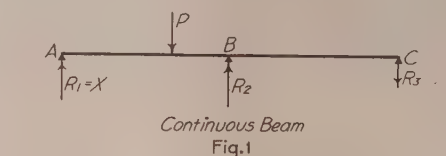
$$M = wax/l \quad (b)$$

Comparing equations (a) and (b), we see that if we take $w = \Delta\phi$, then $d = M$, and the vertical deflections d produced by an angle-change $\Delta\phi$ are equal to the moments

"elastic curve." Notwithstanding the striking usefulness of this device, it is but little known to American engineers. The writer has therefore prepared the following outline of the construction and properties of the elastic curve, using, for concrete illustration, the application of this method to the design of the 1550-ft. continuous trusses of the Sciotoville Bridge described in the Engineering Record of June 26, page 799. Center-bearing swing truss spans, when acting as continuous trusses, can be computed by the exact method here developed.

THEORY OF THE ELASTIC CURVE

A beam or truss continuous over two spans, Fig. 1, or a two-hinged arch, Fig. 2,



ELASTIC CURVE AND GENERAL RELATIONS

M produced by a weight w assumed equal to $\Delta\phi$ and applied at the same point. In other words, the deflection curve produced by the angle-change $\Delta\phi$ is identical with the moment diagram for the weight w .

The quantity w , equal to the angle-change $\Delta\phi$, is called an "elastic weight." By summation, the above principle may be extended to any number of angle-changes and corresponding elastic weights. Since the elastic curve is a curve of deflections, we have proved that the elastic curve is the moment diagram for the angle-changes applied as elastic weights. The angle-changes ($w = \Delta\phi$) must therefore be calculated before the elastic curve can be constructed.

COMPUTATION OF ANGLE-CHANGES

If the contribution of the web stresses to the deflections is neglected, the angle-changes w (measured in radians) are very simply figured by the formula

$$w = \Delta c / r \quad (1)$$

where Δc is the elongation or compression in each chord member due to unit X , and r is the lever arm of the member about its center of moments, Fig. 5. For greater precision, the effect of the web-members is included by using the formula

$$w = \pm (\Delta^1 c - \Delta^1 d_1 - \Delta^1 d_2) / h \quad (2)$$

where $\Delta^1 c$ is the elongation of the chord member multiplied by the secant of its inclination to the horizontal, $\Delta^1 d_1$ and $\Delta^1 d_2$ are the elongations of the two web members multiplied by the secants of their respective inclinations to the horizontal, and h is the vertical altitude of the triangle formed by c , d_1 and d_2 , Fig. 5. In this formula the plus sign is used for angle-changes at the upper panel points and the minus sign for angle-changes at the lower panel points; elongations are taken as positive and compressions as negative.

The values thus found for the angle-changes w between the two web members meeting at each panel point are then treated as "elastic weights" applied at the respective panel points. In order to get zero moments at B and C , the beam AC , with reactions at A and C , is considered hinged at B and C but anchored at A , Fig. 6. The moment diagram is found either by calculation of moments or by construction as a funicular polygon for the weights w . The ordinates of the resulting polygon are then all reduced in a uniform ratio to make the initial ordinate scale unity. We then have the elastic curve of the structure, or influence line for the end reaction X , Fig. 7.

The curve shows that the reaction changes sign as the load passes across the middle pier.

APPLICATION TO SCIOTOVILLE BRIDGE

To illustrate the actual simplicity of the above method of design, the complete work for determining the exact elastic curve for the Sciotoville Bridge is given in the following two tables. Since ratios, not absolute values, are required, the labor is min-

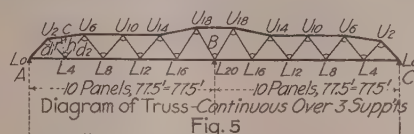


Fig. 5
Diagram of Truss-Continuous Over 3 Supports
Elastic Weights—Considered as Acting on Two Hinged Beam

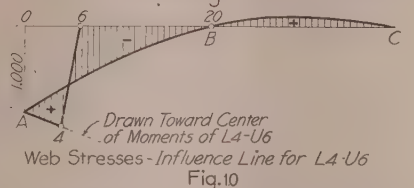
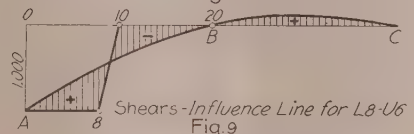
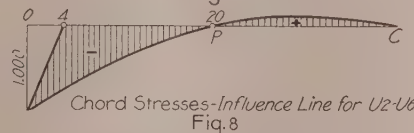
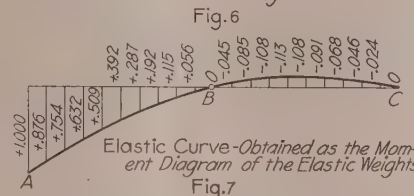


Fig. 10
Web Stresses—Influence Line for L4-U6

imized by calling the length of a panel unity, $E = 1$, etc. In Table 2 a method of summations is used as the most expeditious method of figuring the moments. In this method, after figuring the simple-beam reaction at the free end, all the shears are obtained therefrom by successive addition of the panel loads, and the moments are then obtained by successive summation of

TABLE 2—CALCULATION OF ELASTIC CURVE

Panel Point	Elastic Weight (w)	Shear	Moment	Ordinate
0	0	0	0	0
2	— 36	—502.4	— 502.4	— .024
4	— 22	—466.4	— 968.8	— .046
6	+ 43	—444.4	—1413.2	— .068
8	—142	—487.4	—1900.6	— .091
10	—225	—345.4	—2246.0	— .108
12	—229	—120.4	—2366.4	— .113
14	—378	108.6	—2257.8	— .108
16	—354	486.6	—1771.2	— .085
18	— 90	840.6	— 930.6	— .045
20	—227	930.6	0	0
18	— 90	1157.6	1157.6	.055
16	—354	1247.6	2405.2	.115
14	—378	1601.6	4006.8	.192
12	—229	1979.6	5986.4	.287
10	—225	2208.6	8195.0	.392
8	—142	2433.6	10628.6	.509
6	+ 43	2575.6	13204.2	.632
4	— 22	2532.6	15736.8	.754
2	— 36	2554.6	18291.4	.876
0	0	2590.6	20882.0	1.000

the shears (see Table 2). Ordinarily the results would have to be multiplied by the panel length to give the true moments, but in the present case this factor is unity and the operation otherwise unnecessary. The entire work of figuring the elastic curve with the above devices, as illustrated below, is a matter of only two or three hours at the most. After the elastic curve is determined, the remainder of the design is essentially the same as for a simple structure.

The final results in the last column afford an excellent check upon all the computations in Table 2 in the fact that the ordinates taken in pairs for corresponding panel points of the two spans give arithmetical sums of exactly 1.0, 0.9, 0.8 and so on to 0.0. This necessary relation arises from the fact that the ordinates of the elastic curve above the chord AC are symmetrical about the center line so that the vertical intercepts between the segment AB of the elastic curve and its chord must be identical with the corresponding intercepts of the segment BC .

ELASTIC CURVE FOR THREE DIFFERENT ASSUMPTIONS

The above exact method is the one to be used for the final computation of important structures. For less important or preliminary designs, simpler approximate methods may be used. In the case of the Sciotoville Bridge, three successive designs were made: 1. Preliminary design (approximate); the truss was treated as a beam with constant moment of inertia. 2. The above-outlined method was used, but with the influence of the web members neglected, using equation (1). 3. Final design (exact); the effect of all the members was included, using equation (2) and Tables 1 and 2.

For the first approximation (assuming $I = \text{constant}$), the ordinates of the elastic curve are given directly by the general formula

$$y = 1 - 5x/4l + 1/4(x/l)^3 \quad (3)$$

where l is the length of span AB and x is the abscissa measured from the end A . The sections obtained in this approximation are used as a basis for the succeeding designs. The elastic ordinates for the three assumptions are compared in Table 3.

TABLE 1—CALCULATION OF ELASTIC WEIGHTS

Panel Point	Member	1 Bending Moment M	2 Lever Arm r	3 Stress for $X=1$ S	4 Length l	5 Gross Section A	6 Elongation Δ $3 \times 4 \div 5$	7 Secant	8 Product Δ^1 6×7	9 Altitude h	10 Elastic Weight w $8 \div 9$
				$1 \div 2$							
U2	L0U2	1	0.71	+1.41	1.41	361	56	1.41	+ 79	1	— 36
	L0L4	1	1.00	—1.00	2	315	63	1	— 63		
	U2L4	—5	4.95	—1.01	1.41	189	75	1.41	—106	1.17	— 22
L4	U2U6	2	1.15	+1.74	2.03	361	92	1.01	+ 99		
	L4U6	—5	5.60	+0.89	1.67	138	108	1.67	+180		
U6	L4L8	3	1.33	—2.25	2	474	95	1	— 95	1.33	+ 43
	U6L8	..	..	—1.25	1.67	105	199	1.67	—332		
L8	U6U10	4	1.33	+3.00	2	413	145	1	+145	1.33	—142
	L8U10	..	..	+1.25	1.67	121	173	1.67	+288		
U10	L8L12	5	1.33	—3.75	2	374	158	1	—158	1.33	—225
	U10L12	..	..	—1.25	1.67	238	88	1.67	—146		
L12	U10U14	6	1.33	+4.50	2	317	284	1	+284	1.33	—229
	L12U14	..	..	+1.25	1.67	278	75	1.67	+125		
U14	L12L16	7	1.33	—5.25	2	270	389	1	—389	1.33	—378
	U14L16	—1	7.20	—0.14	1.67	391	6	1.67	— 10		
L16	U14U18	8	1.43	+5.40	2.03	208	526	1.01	+534	1.50	—354
	L16U18	—1	7.71	+0.13	1.94	381	7	1.94	+ 13		
U18	L16L20	9	1.67	—5.40	2	479	226	1	—226	1.67	— 90
	U18L20	..	..	—1.17	1.94	499	45	1.94	— 88		
L20	U18U20	10	1.67	+6.00	1	596	101	1	+101	1.67	—113

TABLE 3—COMPARISON OF ELASTIC CURVES

Panel Point	x/l	1 Assumption $I = \text{constant}$	2 Web Members Neglected	3 All Members Included
0	0	1.000	1.000	1.000
2	0.1	.875	.871	.876
4	0.2	.752	.744	.754
6	0.3	.632	.623	.632
8	0.4	.516	.505	.509
10	0.5	.406	.393	.392
12	0.6	.304	.287	.287
14	0.7	.211	.193	.192
16	0.8	.128	.114	.115
18	0.9	.057	.053	.055
20	1.0	0	0	0
Area AB		4.381	4.283	4.312
Area BC		0.619	0.717	0.688
Sun. of areas		5.000	5.000	5.000

The ordinates for only one-half of the elastic curve are listed in the above table, as those for the other span are quickly obtainable by the check method explained above, i.e., by subtracting the given ordinates of the curve from those of the chord AB. The above table is useful inasmuch as its values can be adopted for the preliminary designs of other structures, thereby saving considerable time and labor. For a structure similar in general outline to the Sciotoville Bridge, the values in column 3 should be used. For girders and trusses with parallel chords, the values in column 1 would be a closer approximation.

A comparison of the areas of the three elastic curves as given in Table 3 indicates that the results of the first assumption may be in error by +2 per cent to -10 per cent, and those of the second approximation by -1 per cent to +4 per cent. In lateral systems, where the web members have relatively small sections, the error of neglecting these members may be much greater; on the other hand, the great uncertainty of lateral forces does not warrant a refined calculation of lateral stresses. For important structures, however, the writer recommends the use of the exact method (3), as the greater reliability of the results is easily worth the slight additional work required.

CONSTRUCTION OF INFLUENCE LINES

After the elastic curve is plotted to any convenient scale, the influence lines for all the members of the truss are constructed by simply drawing straight lines across the curve as illustrated in Figs. 8, 9 and 10. A single plotting of the curve is therefore sufficient for the entire design. The various influence lines are drawn and used in the same manner as for a simple truss, with the single difference that the elastic curve replaces the straight line AB which would ordinarily represent the influence line for the end-reaction.

The customary method of using the above influence lines consists in trying different positions of the specified loading, and comparing the sums of the products obtained by multiplying the scaled ordinates by the respective wheel loads. In the design of the Sciotoville Bridge, however, a great economy of time and effort was effected by the use of equivalent uniform loads. These were taken from a chart, invented by the writer, giving the exact equivalent uniform load for any point of any span. This uniform load value is simply multiplied by the corresponding influence area to give the maximum stress in any member of the structure.

DEAD LOAD STRESSES

For dead load stresses, all the panel dead loads are multiplied by the respective ordinates of the elastic curve and the algebraic sum of the products constitutes the end re-

action. This determined, the stresses are figured exactly as in a simple truss, using the method of summations for shears and moments.

After the details for all connections are worked out, a final adjustment of sections is made for the actual dead load weights determined from the detail drawings. On the close agreement of these actual weights and sections with the values initially assumed depends, to a great extent, the efficient solution of the design.

As outlined above, the elastic curve formed the basis for the design of the Sciotoville Bridge, the longest continuous truss in the world. It was also employed in the design of the Hell Gate arch, another record-breaking structure. Both of these bridges were designed under the direction of Gustav Lindenthal, consulting engineer, to whom the writer is indebted for permission to publish this article.

Cleveland Bases Stairway Regulations on Studies

New Provisions of Building Code Definitely Fix Dimensions, Construction, Maintenance and Egress Facilities

NEXT to the actual structural strength of buildings no question regarding them is of more importance than the means of egress therefrom is the conclusion of V. D. Allen, commissioner of buildings of Cleveland, after making a systematic study

twenty risers are permitted in any flight. Landings must be at the same level as the floors they serve. The length shall be not less than 3½ ft. and the width not less than the width of the flight. Quarter-space landings must be not less in width and length than the width of the widest flight connected to them. The length of half-space landings shall be seven-eighths of the required width of the narrowest flight connected to it. Four feet is the minimum length of floor landing at the exit level of any stair.

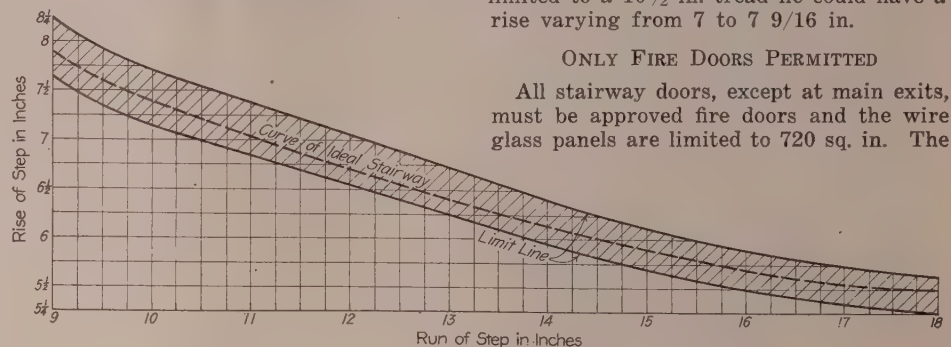
STAIR WIDTHS LIMITED

Both maximum and minimum widths of stairs are fixed, a single-width flight from 2 ft. 3 in. to 2 ft. 9 in. being intended for the use of one file of persons, a double width, from 3 ft. 6 in. to 4 ft. 6 in., for two files, and a multiple width for four or six persons abreast. Handrails, constructed to withstand a pressure of 60 lb. per linear foot, are provided for each file of persons, since it is believed that every person descending a stairway should have a handrail to hold to in case of necessity.

The control of the run and rise of steps is given in the accompanying diagram. The dotted line is the ideal stairway, the limits being worked out from data given by H. Law Olmstead. To use the diagram assume that a 7-in. rise works out best with the floor levels under consideration. The designer could then use a tread ranging from 10½ to 12 3/16 in., or if he were limited to a 10½-in. tread he could have a rise varying from 7 to 7 9/16 in.

ONLY FIRE DOORS PERMITTED

All stairway doors, except at main exits, must be approved fire doors and the wire glass panels are limited to 720 sq. in. The



LIMITING DIMENSIONS OF STEPS, WITH CURVE OF IDEAL STAIRWAY

of the subject of getting out of buildings by means of stairways. He found little reliable data bearing on the question and for that reason the building-code ordinance embodying his findings is here reviewed. There are five sections, general in application, referring to all stairways hereafter constructed, and seven sections dealing with stairways for public and semi-public buildings. School buildings and theaters are not included, since they are regulated by the State code.

Some of the more important features in the regulations are as follows: Under definitions the words flight, stair and stairway each have a distinct meaning, whereas in most codes and in most literature these words are used indiscriminately. Flight is defined as an unbroken succession of steps between landings, stair as all the flights and landings between two successive floor levels, and stairway as all the flights and landings together with the inclosing walls and partitions and the doors leading thereto and therefrom, extending from the exit level to and including all stories served by such stairs.

In the regulation of treads and risers winders are prohibited and no more than

width is to be the same as the stair width. Exit doors swing out, and others in. At least one stairway in every building shall be continuous from the exit level to the roof. Whenever four or more stairways are required, at least two, located as far apart as practicable shall extend to the roof.

Under the maintenance provision the stairs must be kept in perfect repair. No goods may be stored in the lighted stairway. No stairway or exit door is to be locked when the building is occupied, except with approved panic hardware, and all but main doors are to be kept closed.

One section provides for special stairways of a monumental nature, or service stairways connecting one or more floors so that the department may issue a permit without violating the regulations. This is to give a degree of elasticity which is desirable and at the same time protect the public.

TO INCLOSE the Ashokan Reservoir, a part of New York City's new water supply, nearly forty-one miles of wire fence on concrete posts were erected at a cost of \$67,600.



CONCRETE VIADUCT OVER HANGMAN'S CREEK, SPOKANE, REPRESENTS ONE THE LARGE IMPROVEMENTS RECENTLY COMPLETED THERE

The Engineering Works of the West

Brief Notes on Engineering Structures Designed to Serve as a Guide to Engineers Who May Wish to Inspect Works in Cities En Route to or from the International Engineering Congress at San Francisco

ENGINEERS from the East and the Middle West, who will attend the International Engineering Congress at San Francisco, Sept. 20-25, and the conventions of the national technical societies, Sept. 16 and 17, will have an opportunity of inspecting, either on the outward or the homeward-bound trips, many engineering works of interest in the cities en route. In order to furnish to these men a convenient guide to the more important works, the Engineering Record presents herewith brief notes prepared from replies to requests for information along these lines. No attempt has been made to give anything more than a suggestion as to the nature of the structures and their location. From the list

published, however, the engineer can select those works which are of particular interest to him and which, in his opinion, would warrant inspection. It may aid him in selecting his railway route and planning a trip of maximum usefulness.

Along the Railroads

Atchison, Topeka & Santa Fé.—Missouri River Bridge, near Sibley; length 4082 ft.; east approach steel viaduct, length 2592 ft.; three 396-ft. spans; base of rail 55 ft. above water. Horse-shoe curve 25 miles west of Las Vegas; central angle 200 deg. Raton Tunnel, at an elevation of 7600 ft., length of bores 2789 ft. and 2038 ft. respectively. Opposing grades over Raton range; west bound 185 ft. per mile, east

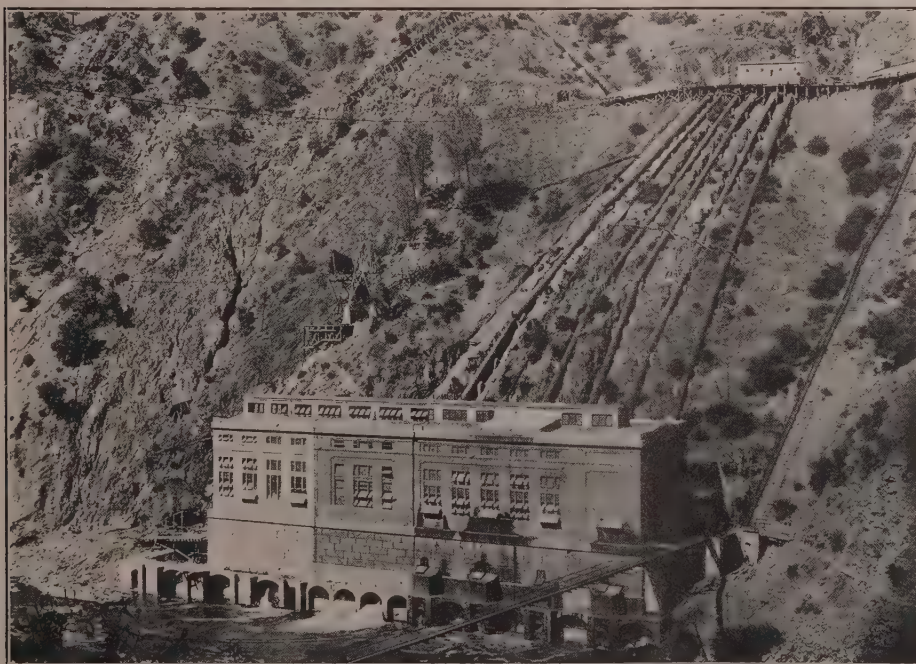
bound 175 ft. per mile. Embankment more than 2 miles long and 50 ft. high just west of Vaughn, N. M.; contains 860,000 cu. yd. of fill. West of Dalies, N. M., line crosses continental divide at elevation of 7259 ft. At points between Albuquerque and Barstow line traverses extensive lava flows, and, east of Barstow, runs near numerous volcanic craters.

Northern Pacific.—Grade revision west of Staples, Minn. U. S. Irrigation project at Huntley, Mont.; line runs directly through it. Double-track bridges across Columbia River, north of Portland, Ore. Construction of terminals in Spokane.

Western Pacific.—Near Salt Lake City, road built through and across Great Salt Lake for distance of 11 miles, with solid rock embankment containing 625,000 cu. yd. Arnold's Loop; 147 miles west of Salt Lake City; built in order to hold maximum grade; 10.6 miles long. Largest and longest cut on road; on Arnold's Loop; 2.2 miles long, 600,000 cu. yd. of material. William's loop 6 miles west of Portola; makes complete circle, crossing over itself; 4842 ft. around.

Great Northern.—Double-track stone arch bridge across Mississippi River, entering Minneapolis from St. Paul; three arches, 40-ft. spans; sixteen arches, 80-ft. spans; four arches, 100-ft. spans; only structure entirely of masonry across Mississippi River. Snow sheds in Cascade Mountains, Washington. Timber, concrete and combination drawspan of Willamette River bridge; longest double-track swing in the world.

Chicago, Burlington & Quincy.—For those who are desirous of seeing Yellowstone Park en route to the coast the "Burlington" takes one via Omaha to Cody, Wyo. At Cody, on the west side of the park, the "Wylie Way" overland wagon trip may be taken through the Park to the Northern Pacific Railroad's terminus at Gardiner, Mont. En route to Cody, between Casper and Thermopolis, Wyo., a 800-ft. summit



HYDROELECTRIC PLANT AT LAS PLUMAS HAS CAPACITY OF 50,000 KILOWATTS

tunnel has recently been completed in connection with the construction of the Big Horn Basin line extension of the "Q." See Engineering Record of Oct. 31, 1914, page 493. Those desiring to go through a virgin country may go via Denver and Orin Junction to Cody, over the newly constructed line.

Denver & Rio Grande.—The Royal Gorge with its original hanging bridge. Surmounts the continental divide at an elevation of 10,239 ft., from an elevation of 4672 in a distance of 171 miles. Road crosses six distinct mountain passes, over 9000 ft. in elevation; four over 10,000 ft. and one over 11,000 ft.

Denver

Lookout Mountain Drive.—Part of State Road system. Rises 1500 ft. in six miles.

Cherry Creek Improvements.—Include concrete bridges of mushroom type of reinforcement and one of hinged arch type.

Colfax-Larimer Viaduct.—X-shaped structure; length of arms 2937 ft. and 5544 ft. respectively; extends across several railroad yards and the South Platte River. Long spans are of steel, others of reinforced concrete. Estimated cost \$800,000. Now under construction.

Galveston

Concrete Seawall.—Length $4\frac{1}{3}$ miles; cost \$1,800,000.

Rock Jetties.—Total length $11\frac{2}{3}$ miles; cost \$10,000,850.

Concrete Causeway.—Connects Galveston Island to mainland; length over 2 miles; cost, about \$2,000,000.

Cotton Compresses and Warehouses.—Said to be largest in world; reinforced concrete construction.

In view of the recent storm the condition of Galveston's engineering works is of timely interest.

Houston

Ship Channel.—From Galveston Bay to Houston, 50 miles. Dredged to 25 ft. depth and 100 ft. bottom width.

Concrete Bridges.—Capitol Avenue Bridge; girder type; reinforced concrete construction; 870 ft. long and 62 ft. wide;



CONCRETE STADIUM AT TACOMA HAS SEATING CAPACITY OF 30,000

cantilever supported sidewalks on each side. Cost \$164,332. San Jacinto Street Bridge; 500 ft. long and 70 ft. wide; reinforced-concrete arch, skewed 25 deg. from right angle, span of arch 110 ft. on skew. Cost \$113,307. Franklin Avenue Bridge; girder type, reinforced concrete; triangular, conceals unsightly banks of dirty bayou. Cost \$129,843.

Kansas City

Terminal Railway Improvements.—Aggregating over \$35,000,000 in cost; including heavy cuts and fills, 13 street subways, 26 street viaducts, retaining walls, and freight stations.

Twelfth Street Viaduct.—Reinforced-concrete double-deck structure described in the Engineering Record, Feb. 6, page 164. Cost \$595,000. Recently completed.

Drainage Improvements.—Several miles of levees along Kaw River. Some riprapped, other portions protected by concrete and concrete slab mattress, made of concrete blocks strung on galvanized wire cables.

Waterworks.—Missouri River water

treated by settling basins and hypochlorite, and mechanical filtration and lime.

Los Angeles

Los Angeles Aqueduct.—Largest of engineering projects of city.

Municipal Harbor Work.—Dredging and construction of docks and warehouses.

Flood Control Work.—Studies for rectification of stream courses and construction of protective structures.

Arroyo Seco Bridge.—Of reinforced concrete; between Los Angeles and Pasadena; short trolley ride.

Minneapolis

Reinforced Concrete Bridge.—Five spans, 211 ft. in the clear and several smaller spans 80 ft. width. Now under construction across Mississippi River.

Filtration Plant.—Nearing completion. Capacity 60,000,000 gal.

Great Northern Passenger Station.—Cost \$2,500,000. In course of construction. Put into service last year.

Track Depression Work.—In course of construction by Chicago, Milwaukee & St. Paul Railway. Thirty-seven concrete bridges for carrying streets across tracks.

New Orleans

Cotton Warehouses and Dock Improvements.—Work to the value of \$1,000,000 under construction. Described in the Engineering Record, May 27, page 402. Eventual expenditure of \$3,000,000 contemplated.

West End Lake Shore Park Improvement.—Dredging and filling work in progress. Extensive landscape work projected. To cost \$350,000.

Drainage and Land Reclamation.—Numerous large canals being constructed. Thousands of acres of low lands already reclaimed.

Railroad Terminals and Track Work.—Trans-Mississippi Terminal Company constructing new terminals. Louisville & Nashville has considerable track rearrangement under construction.

Portland, Ore.

Columbia River Scenic Highway.—Follows bluffs along gorge where Columbia River breaks through the Cascade Mountains.



LAKE WASHINGTON CANAL LOCKS AT SEATTLE SHOWN UNDER CONSTRUCTION

Westover Terrace Regrade.—High hillside, regraded by sluicing, to form stepped residential section.

Railroad Bridge Across Willamette River.—Upper deck for street traffic. Lower for railroad. Vertical-lift type drawbridge. Lower deck can be raised to pass low clearance boats without disturbing upper deck.

Dalles-Celilo Canal.—Cost \$5,000,000; overcomes series of falls and rapids in Columbia River.

Hydroelectric Developments.—Bull Run plant; 11,250 kw. capacity, 320 ft. head, 30 miles from city. White Salmon; 12,000 kw. capacity, 160 ft. head, 1½ miles of largest wood-stave pipe line ever built; 72 miles from city.

Salt Lake City

Parley's Canyon Intake Reservoir.—Capacity 2,000,000 gal.



LEFT — COLFAX-LARIMER VIADUCT, DENVER, TOTAL LENGTH 8400 FT.

Distributing Reservoir.—Capacity 10,000,000 gal. Concrete lined. In course of construction.

Intercepting Sewer Pumping Station.—Capacity approximately 35 sec.-ft. Head 48 ft.

Fourth South Street Viaduct.—Steel and reinforced concrete, approximately 1800 ft. in length, crossing track of Denver & Rio Grande Railroad.

Jordan Narrows Dam.—Twenty miles from city. Reinforced concrete and provided with measuring weirs. Height 20 ft., length 90 ft.

St. Louis

Filtration Plant.—Largest rapid sand filter in the world. Cost \$1,300,000. Capacity 160,000,000 gal. per day. Has 40 filter units 50 x 28 ft. Illustrated in Engineering Record, May 8, page 578. Buildings of reinforced concrete.

Mill Creek Relief Sewer.—Estimated cost of project \$3,000,000. Now under construction. Concrete lined pressure tunnel in rock. Excavation under way from nine shafts. Reinforced concrete work in progress in open cut section.

Municipal Bridge.—Work under way on east approach of Municipal Bridge over Mississippi River involves at present reinforced-concrete work and caisson sinking. Steel work to be started in summer.

Viaducts.—Twelfth Street Viaduct; reinforced-concrete structure 2049 ft. long and 79 ft. high. Spans vary in length from

30 to 54 ft., cost \$380,000. The Tower Grove viaducts, built by railroad companies to eliminate grade crossings. Reinforced concrete. Estimated cost \$650,000.

Municipal Buildings.—Jail building to accommodate 288 prisoners with space for cells for 192 in addition. Cost \$300,000. Isolation hospital to consist of group of twelve buildings and cost \$1,000,000. Two under construction will cost \$135,000 each. Mullanphy Playground. Comfort station and open air swimming pool. Cost \$27,000.

St. Paul

Lock and Dam Project.—Ambursen type dam; 30 ft. head. Across Mississippi River. To be used as aid to navigation and for power development. Now being constructed by U. S. Government.

New Union Depot.—Estimated cost \$15,000,000. Construction under way. Work

Dams.—Cedar River, 200 ft. high, 1000 ft. long. Seepage conditions that have developed in it have aroused widespread interest among engineers. Keechelus, 170 ft. in height and 6500 ft. long, estimated cost \$1,350,000.

Stampede Tunnel Ventilating System.—Installed in Northern Pacific's 2-mile tunnel through Cascade mountains.

Hydroelectric Developments.—Five high head plants within easy reach of city: Snoqualmie, Lake Tapps, Puyallup, the city of Tacoma's Nisqually plant and Seattle's Cedar River plant. These range from 284 ft. to 878 ft. in head and aggregate about 75,000 kw. in installed capacity.

Spokane

Reinforced-Concrete Bridges.—Monroe Street Bridge. Central span 281 ft.; total length 786 ft.; total height 140 ft.; 24,000 cu. yd. of concrete used in this structure, cost of which was \$500,000. Latsh Bridge, 1043 ft. long and 140 ft. high, contains 42,000 cu. yd. of concrete and cost \$440,000.

Railway Bridges.—Three railway bridges having height of from 125 ft. to 175 ft.,



RIGHT — CANTILEVER SUPPORTED SPAN OF COLFAX-LARIMER VIADUCT

involves reconstruction of number of bridges and changing channel of Mississippi River.

Seattle

Concrete Structure 172 Feet High.—Grain elevator 172 ft. high built of reinforced concrete, said to be highest reinforced concrete structure in the world.

Harbor Works.—Docks, warehouses and storage plants to the value of \$5,000,000 have been constructed within the past three years. Further expenditure of \$3,000,000 is contemplated in projects already approved.

"Sanitary Fills."—City has developed method of depositing mixed refuse upon low areas and subjecting it to special treatment which renders it innocuous and inoffensive. New method saves at least \$150,000 a year and should prove of interest to municipal engineers.

Drydock.—At Bremerton navy yard. Completed in 1913. Cost \$2,300,000.

Lake Washington Canal and Locks.—Project estimated to cost \$3,500,000. Main lock one of largest in country. Dimensions over upper sill 80 x 825 x 37 ft.

presenting conditions exceptional in this country.

Municipal Water Supply.—Source in underground river, pumps driven by power from an adjoining stream. Reservoir of concrete slab construction, capacity 24,000,000 gal.

Hydroelectric Plants.—Five in number, one of which has spillway dam approximately 180 ft. in height. They develop 90,000 hp.

Railway Grade Elimination Work.—Approximate cost \$2,000,000. Construction, now in progress, consists of elevation of six track terminal layout over a mile long, described in Engineering Record, Feb. 20, page 235.

Tacoma

Port Defiance Tunnel.—Length 4391 ft. Inside dimensions 28 ft. by 27 ft. Construction described in Engineering Record, Feb. 27, page 272.

Stadium.—Reinforced concrete. Seating capacity 30,000.

Vancouver

Sewer System.—Total cost will be \$5,000,000. Vary in diameter from 11½ ft. to 15 ft. Interceptor and outfall.

Viaducts.—Georgia-Harris: Reinforced concrete; 2860 ft. long; cost \$500,000. Under construction. Kingsway: Cost \$950,000; completed.

Longest Tunnel in America.—Rogers Pass Tunnel: 26,400 ft. long. Said to be longest in America. Concrete lined. Under construction for Canadian Pacific Railway. Described in the Engineering Record, Dec. 5, 1914, page 604, and progress records noted on page 209 of Aug. 21 issue.

Hydroelectric Plants.—Coquitlam-Buntzen: hydraulic fill dam; height 99 ft.; length 950 ft.; capacity of lake in electric energy, 60,600,000 kw.-hr. Stave Falls plant; two dams; reservoir area 18 square miles, continuous capacity 28,000 hp.

Victoria

Breakwaters.—Cost \$3,000,000. Four piers to be constructed; each 250 ft. wide and 800 to 1000 ft. long. Reinforced concrete cribs. Under construction.

New Water Supply System.—Sooke Water Supply System. 27.3 miles of gravity flow concrete pipe to carry 16,000,000 gal. daily. Balancing reservoir and 10 miles of steel main. Completed.

Jordan River Power Development.—Hollow reinforced-concrete dam of Ambursen type, 891 ft. long and 126 ft. high. Reservoir capacity 940,000,000 cu. ft.

Hydroelectric Plants in California

Great Western Power Company.—Big Ben Power Station; said to be largest on Pacific Coast; located directly on line of Western Pacific Railroad at station of Los Plumas; comprises five 10,000 kw. turbo-generators, operating under 450-ft. static head.

Pacific Gas and Electric Company.—Colgate power house; head 716 ft.; installed units total 14,860 kw. Plant located one day distant from San Francisco. De Sabla power house; one day distant from San Francisco; head 1531 ft.; capacity 19,400 kw. Electra power house; located in Amador County; development of a great many small lakes in upper Sierras; static head, through one pipe line, 1267, through a second, 1195; capacity 20,000 kw.

Southern California Edison Company.—Santa Anna River and Mill Creek plants; among first hydroelectric plants built in the United States; both located at Redlands; head at first, 760 and 304; capacities 4000 hp. and 1350 hp.; head at second 510 and 1960; capacities 1000 hp. and 5550 hp. Lytle Creek Plant; located at San Bernardino; head 483 ft.; capacity 650 hp. Kern River; capacity 30,000 hp.; head 874; located at Bakersfield.

City of Los Angeles Plant.—San Francisco, No. 1; under construction; 14,000 hp. capacity per unit. Located 45 miles from Los Angeles.

U. S. Reclamation Projects

Elephant Butte Dam.—Fourteen miles west of Engle, N. M., on Santa Fé. Rubble concrete; gravity type; maximum height 290 ft.; crest length 1200 ft. Volume about 500,000 cu. yd. Nearing completion.

Roosevelt Dam.—Rubble masonry arch, of gravity type. Maximum height 280 ft. Length at crest 1125 ft. Contains 342,325 cu. yd. of masonry. Completed. About 20,000 hp. of electric energy are developed by plants at the dam and at drops in the valley canals. Change on Southern Pacific at Maricopa for Phoenix, or at Bowie for Globe.

Laguna Dam.—Height 40 ft. Length 4780 ft. Concrete and rock structure. Contains 441,732 cu. yd. Levee system of levees along Colorado River. Reached by Southern Pacific.

Lahontan Dam.—Earth and gravel fill structure. Height 129 ft. Length 1700 ft. Volume 770,000 cu. yd. 31 miles of concrete lined canal. Stepped spillways curving from each end of dam to a pool below. Leave Southern Pacific at Hazen, Nev.

Strawberry Dam.—Built in mountains at elevation of about 7500 ft. May be reached from Salt Lake City by rail to Provo, Utah. Earth fill with concrete core. Height 72 ft. Length 488 ft. Volume 108,415 cu. yd.

Grand River Dam.—Roller crest extend-

ing across. Six rollers each 70 ft. long and 10 ft. high, and one 60 ft. long and 15 ft. high. Masonry ogee weir; 546 ft. long and 24 ft. high. Nearing completion. In Grand Valley, Col., along Denver & Rio Grande Railroad. Described in Engineering Record, Aug. 14, page 209.

Arrowrock Dam.—20 miles up river from Boise, Idaho. Rubble concrete arch, 350 ft. high 1075 ft. long. Will contain about 600,000 cu. yd. Under construction.

Minidoka Dam.—10,000 hp. hydroelectric plant. Largest power installation of the kind used for irrigation pumping. Pumping plants. Rockfill dam with concrete core; 86 ft. high; 937 ft. long; contains about 242,500 cu. yd. Located near Boise, Idaho.

Philippine Road Built at High Level to Escape Flood Damage

Baguio-Bauang Route Replaces the \$2,000,000 Benguet Road Which Involved Excessive Maintenance Charges

LOCATED near the summits of mountain ridges so as to minimize the possibility of damage by floods, the newly completed Baguio-Bauang road in the Philippines, which links the sea-coast with the health resort at Baguio, will practically

located near the summit of the hillside in the mountain section and ridges that it follows and consequently will be subject to rainfall discharges from a very limited watershed. Another important advantage in the location of the new road is the lesser number of bridges required.

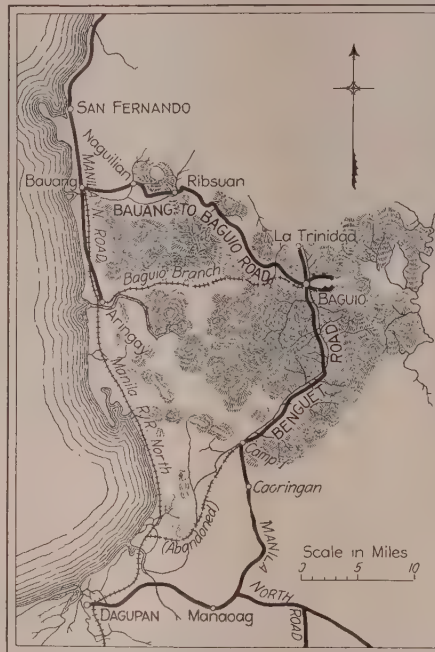
GENERAL ROUTE FOLLOWED

The new road leads out of Baguio in a westerly direction for 5 miles along the old Spanish Naguilian trail, improved by the city of Baguio so as to be classed as a second-class road, and, thence, over 17.4 miles, improved in 1914, to the village of Ribsuan. From this point, 5 miles west to Naguilian, it follows along a section of first-class road, replacing a section of the Naguilian trail, and from there to Bauang over another section of 5 miles of first-class road. The latter city is on the road leading to Manila and to the harbor of San Fernando, where extensive harbor improvements are contemplated. It is also on the railroad to the former city. The total distance from Baguio to Bauang along the road is 31 miles. From Bauang to San Fernando the distance is 6.2 miles. The lower sections of the road represent, for the most part, a new location.

Between Bauang and Naguilian the old Spanish road was, for practically the whole distance, in the high water channel of the Bauang River. The new road is located on the bank, well above high water. It passes through a typical foot-hill section broken by numerous drainage courses and low ridges, necessitating frequent adverse grades and curves. In the location of the Naguilian-Ribsuan section little value was attached to the trail and the present road coincides with it in about two places through villages. From the low level surrounding Naguilian and crossing a number of low line ridges necessitating adverse grades, the road is in side-hill cuts bordering the Ribsuan River to the crossing at the village of Ribsuan.

LOCATION AND CONSTRUCTION

The location of the mountain section from Ribsuan to Baguio consisted mainly in revising the alignment and grade of the old trail. In the mountain section of the road it was placed as near as possible to



NEW HIGHWAY REPLACES BENGUET ROAD

supersede the old Benguet road, built at a cost of \$2,000,000, and ravaged to such an extent by floods from a watershed 6000 ft. above it that a million dollars has been spent on its maintenance during the last 10 yr. The old Benguet route was described in the Engineering Record of Dec. 23, 1905, page 702, while the following notes on the new road are from an article by A. D. Williams, district engineer, published in the April Quarterly Bulletin of the Philippine Bureau of Public Works.

In the vicinity of the Benguet road excessive rainfalls, amounting to 46 in. in 24 hr. have been recorded. The resulting damage to the surfacing was so severe that maintenance costs were excessive. The Baguio-Bauang road, on the other hand, is

the top of the ridge, passing over a series of saddles or low connecting ridges for the entire distance to Baguio. This eliminated large drainage areas above the road and the necessity for placing large drainage openings under the road. Construction work on the lowland sections was done during the dry season of 1912 and 1913 without the necessity of haste or the employment of large forces. The cost of this portion of the road compares favorably with the average cost of lowland construction elsewhere in that locality. Construction work on the Benguet section was started Jan. 20, 1914, and continued through the rainy season. Grading was completed Dec. 20, and the surfacing, March 25, 1915. The largest labor organization at any time during the work was seven foremen, fourteen sub-foremen and about 2500 laborers. A total of 8.6 miles of the road was graded by force account at an average cost of about 15 cents per cubic meter for moving earth and \$1 per cubic meter for moving rock. The road is in side-hill cut for practically the whole distance and grades and curvature of the old trail were reduced by heavy cutting and filling. Solid rock work was encountered on 1.4 miles of the road and approximately 16,000 cubic meters of rock were moved from cuts and

account. Excavation was done by contract during the rainy season where water was available for sluicing as low as 4 cents per cubic meter, the contractors being familiar with this method of excavating as it is the usual practice in constructing hillside rice paddies in the mountain provinces.

NO LARGE STRUCTURES REQUIRED ON MOUNTAIN SECTIONS

It was often necessary for contractors to build ditches over 1600 ft. long to secure a sufficient amount of water for sluicing heavy cuts. Material required for making fills was sluiced into place and held by dry rock walls or sheet piling made tight with banana leaves or grass. The sections of the road graded by contract were left with slopes varying from $\frac{1}{4}$ on 1 to 1 on 1, according to the materials encountered. No large structures were required in the mountain sections, but a large amount of dry-rubble masonry was used in con-

struction outside of the roadbed to keep drainage from going over the slope of fills and by planting grass on the slopes of high fills so as to form a cover against rain. The maximum gradient used was 9 per cent and the minimum radius of curvature 50 ft. In several places where it would have been necessary to resort to heavy cutting and filling to correct the grade of the old trail the minimum radius of curvature was reduced to 33 ft. Wherever a radius of curvature less than 50 ft. was used the roadbed was widened and the gradient compensated by reducing the gradient on the curve. The maximum grade was on the section near Ribsuan, where the road makes an ascent of 765 ft. The total ascent from Ribsuan to Baguio aggregates 0.94 mile and the total descent $\frac{1}{2}$ mile.

There are 303 minor structures on the mountain section of the road with openings for drainage aggregating 750 ft. total span, as compared to a total of 234 struc-

RIGHT — NATIVES DISPLAYED GREAT SKILL IN DRY RUBBLE WORK



LEFT — ROAD WAS CONSTRUCTED NEAR CRESTS OF RIDGES ALONG ROUTE



side hills. The road was then laid out and constructed with a 20-ft. roadbed both in cuts and fills, except on two sections where heavy rock was encountered, where there is a 15-ft. roadway.

DID NOT CUT HIGH SLOPES TO STAND

On the upper section of the road, graded before the 1914 rainy season, no attempt was made to cut high slopes to stand, the idea being that it would cost less to move the material brought down by the rain. The result was that the first heavy rain and later rains caused a large amount of sliding from the upper banks. This material was moved to advantage with two-mule drag scrapers at a cost of about 5 cents per cubic meter or a total cost of \$11,404.20, which represented the saving in excavation of \$22,808.40. A portion of the road, $7\frac{1}{2}$ miles long, was graded by contract at a total cost of \$8,342, or at an average cost of 8 cents per cubic meter. Parts of the road were done by contract, practically all the contractors being natives. The system proved not only very satisfactory but about 50 per cent cheaper for excavation than for that done by force

account. Excavation was done by contract during the rainy season where water was available for sluicing as low as 4 cents per cubic meter, the contractors being familiar with this method of excavating as it is the usual practice in constructing hillside rice paddies in the mountain provinces.

All material used in surfacing the road was contracted for and broken by hand along the roadside. The cost of breaking and quarrying varied from 30 to 55 cents per cubic meter, for the first course, and from 45 to 60 cents for the second course and finishing material, the government furnishing the tools and dynamite. The breaking and delivering of rock was contracted for on 15 miles and the price paid was from 90 cents to \$1. The maximum haul in the upper section was about $1\frac{1}{4}$ miles with an average haul of 650 ft. The maximum haul was 2.2 miles on the lower sections. Two 8-ton and two 10-ton road rollers were used in preparing the sub-grade and rolling surfacing material into place. A 6-ton roller was used in rolling fill.

PROTECTION OF SLOPES

Special attention was given to the protection of fills by placing banks on the

outside of the roadbed to keep drainage from going over the slope of fills and by planting grass on the slopes of high fills so as to form a cover against rain. The maximum gradient used was 9 per cent and the minimum radius of curvature 50 ft. In several places where it would have been necessary to resort to heavy cutting and filling to correct the grade of the old trail the minimum radius of curvature was reduced to 33 ft. Wherever a radius of curvature less than 50 ft. was used the roadbed was widened and the gradient compensated by reducing the gradient on the curve. The maximum grade was on the section near Ribsuan, where the road makes an ascent of 765 ft. The total ascent from Ribsuan to Baguio aggregates 0.94 mile and the total descent $\frac{1}{2}$ mile. There are 303 minor structures on the mountain section of the road with openings for drainage aggregating 750 ft. total span, as compared to a total of 234 structures on the Benguet road having a total length of 7450 ft. For small drainage openings where rock was easily obtainable dry rock box culverts were used instead of pipe drains. The cost of building these culverts was about half the cost of concrete or galvanized iron pipes. In locations where it would have been necessary to place pipe culverts under high fills to take care of drainage and natural water courses the ravines were filled so as to divert the drainage and the pipes placed in cuts. This necessitated larger fills that eliminated high end walls on culverts. The only bridge and timber structure on the mountain section is a 60-ft. pony truss bridge, with girder approaches, across the Irian River. This bridge was built during 1912 by the city of Baguio. It was designed for a maximum load of 8 tons but has been strengthened to carry 10 tons and will be serviceable for several years longer. Timber collapsible bridges are used at the Ribsuan and Naguilian River crossings. A good bridge site, however, is available at the Ribsuan River and it is proposed to replace the present collapsible bridge with a 300-ft. steel structure during the coming year.

WIDTHS AND KINDS OF METALING

The metaling on the road has been placed 13 ft. wide in sections and increased in width on curves depending on the radius of curvature. In order to effect a saving in the construction the width of metaling

was reduced to 10 ft. on one section. The depth of metaling varied from 6 to 9 in. and different classes of material were used. City sections of the road were of a good quality of limestone rock, some sections were gravel and others of rock easily obtainable along the route and varying from a diorite or andesite to a fair quality of sandstone for first course material, and the best grade material was used for the finishing courses. In order to provide a better wearing surface for the heavy traffic to which the road will be subjected it is proposed to resurface the entire road later and to widen the section with 10 ft. of metaling of an excellent quality of hornblende and andesite and with limestone from the city of Baguio. This class of material will also be used to make country roads.

The total cost of the road was less than \$320,000. What will ultimately be done with the Benguet road is as yet uncertain. At present it is being used as a toll road for lighter traffic, and the receipts have been ample to pay for maintenance. If this continues it will probably be kept open for such a purpose, but otherwise it will probably be abandoned altogether.

The location and construction of the

Central Plant at Chicago Will Handle Repairs to All City Equipment

All Municipal Shops to Be Consolidated at Site in Heart of City—Construction Features Described—Concrete Is Sent 400 Feet through Chute to Caissons

CHICAGO'S new Marshall Boulevard municipal plant, located in the geographical heart of the city at Thirty-first Street and South Sacramento Avenue and designed to replace the various overcrowded municipally owned shops scattered throughout the city, is rapidly nearing completion. The buildings, which include a machine shop, a foundry, a blacksmith shop, a garage and office building, a warehouse and a combined carpenter, pattern and paint shop, and a pattern warehouse will have complete facilities for making repairs to any of the city's property.

WHERE REPAIRS WERE MADE HERETOFORE

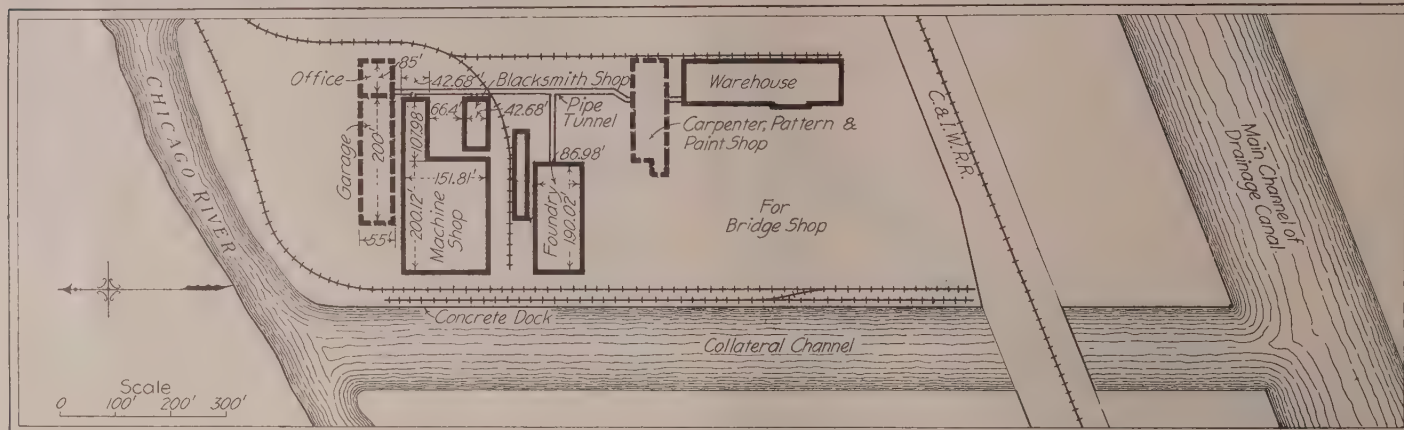
In the sixty-two years that have elapsed since Chicago's first pumping station was constructed in 1853 the pumping equipment of 8,000,000 gal. per day has had to be increased until to-day the city has nine pumping stations with a capacity of 840,-

shop. The tugs heretofore could not get closer to their repair shop by water than $\frac{1}{2}$ mile, which made tug repairs costly. Two railroads have spurs running to the shops which will aid in handling materials to and from the work. A complete sewerage system for both sanitary and storm purposes has been installed.

The shops and railroad tracks have been laid out so as to facilitate the work and make the minimum amount of handling of patterns from the pattern shop to the foundry and the castings from the foundry to the machine shop and through the assembly rooms.

CONSTRUCTION FEATURES

Of the various buildings being erected the four-story reinforced concrete warehouse, which is now nearing completion, and its near neighbor of similar design, the carpenter shop, present the most inter-



CHICAGO'S NEW MUNICIPAL REPAIR PLANT IS LOCATED NEAR THE GEOGRAPHICAL HEART OF THE CITY

Buang-Naguilian and the Naguilian-Ribuan sections of the Baguio-Buang Road was under the supervision of E. D. Smith, district engineer. The section from Ribuan, kilometer 32, to kilometer 34 was located and constructed by Dana A. McComb, also district engineer. The mountain section of the road from kilometer 32 to Baguio was under the supervision of A. D. Williams, district engineer, assisted by J. E. Evans. E. A. Eckman had charge of the work of converting the old Naguilian trail into a cart trail.

RAILROAD DEVELOPMENT IN NIGERIA, states a recent consular report, has been as rapid in the last few years as in any part of West Africa. The railroad system, which is controlled by the British Colonial Government, now extends nearly 800 miles into the interior. The ocean terminus is at Lagos, the main seaport of the colony. The main line runs northeasterly 712 miles to Kano, the principal town in the Mohammedan States of northern Nigeria. From Minna Junction is a branch south to Baro at the head of the permanently navigable section of the River Niger, while a second branch, opened last December, runs from Zavia to Bukuru, reaching rich tin deposits. The entire system is of $3\frac{1}{2}$ -ft. gage.

750,000 gal. per day from forty-two pumps. These pumps, all but two of which are steam-driven, are served by sixty-two boilers with a rating of 15,344 hp. The distribution system now includes 2524 miles of pipe of all sizes, 26,984 fire hydrants and 22,716 gate-valves. As the system grew it became necessary to build repair shops, which were developed at different locations as space could be obtained.

In the same manner as the water department the fire and police departments have, as they grew, developed shops for repair work. The shops, aside from being scattered, were compelled to increase their output each year until each was so badly crowded that the city decided in 1913 to erect a central compact municipal plant which could handle all types of repair work. Land was purchased and the erection of buildings started toward the end of 1914.

LAYOUT OF THE NEW PLANT

The accompanying diagram shows the general layout of the plant. The buildings are so designed and arranged that extensions can be made easily. A concrete dock 1100 ft. long is being built for that portion of the grounds along the collateral channel, thus allowing the fire tugs to tie up for repairs within a few feet of the machine

esting construction problems. Conforming with what has been declared to be good practice since the Edison fire, the round columns supporting the Acme flat-slab system predominates. The warehouse has seventy-five piers all but eighteen of which are round. The few square columns are used at the stair wells. Concrete work for the entire building above the basement foundations, including stairways, elevator pits and tower, was poured by chutes. The cement shed is located next to a $\frac{1}{2}$ -cu. yd. Chain Belt mixer, thus doing away with the wheeling of cement. Stone and sand are unloaded by a Browning crane from railroad cars directly into a hopper located over the mixer. Water is obtained from a barrel provided with a water gage which enables the operator to supply the exact quantity needed for each batch. The mixer averaged 200 cu. yd. per 8-hr. day, although it frequently reached a maximum of 230 cu. yd.—a batch a minute.

The floor forms were made of sectional panels which were used many times on the different floors. The first floor of the warehouse was poured when the temperature ranged from 2 to 7 deg. Fahr. below zero. From thirty to forty salamanders were kept 4 ft. below the floor which was covered above with canvas with an air space of 6 in. between the floor and the



CHUTING CONCRETE 400 FEET TO CAISSONS FOR CARPENTER BUILDING

canvas. No frost action whatever was encountered.

CAISSON CONCRETE CHUTED 400 FEET

Owing to its accessibility to the railroad tracks a few feet away, and as steam was furnished the mixer from a small power plant nearby, it was deemed unnecessary to move the mixer plant in building the carpenter shop. As a result the unusual method of pouring caissons by chute was arranged. The concrete is thus spouted from mixer tower approximately 400 ft., this includes a vertical drop of 50 ft., directly into the forty-two caissons of the new building. The entire carpenter shop, with the exception of the roof, will be poured by the same plant. Unusual soil conditions were encountered in placing the caissons as in nearly every one of the forty-two which were sunk the stratum was found to vary. Quicksand varying in depth from 1 to 11 ft. added to the difficulties.

Bayley metal sash and wire glass as well as sprinkler systems will be used in the buildings as fire preventive measures.

ELABORATE EQUIPMENT TO BE INSTALLED

The machine shop and blacksmith shop are so constructed that when it is necessary to enlarge the machine shop the bay

separating the machine shop and blacksmith shop can be filled in and the area between the blacksmith shop and north wing extended can be roofed over, making a complete machine shop 308 ft. long. As planned at present, when such an extension is made a new building will be constructed for the blacksmith shop. The main part of the machine shop will contain the heavy machine tools for working on large castings. All the modern tools in the present shops will be moved and about \$25,000 worth of new tools added. A 25-ton Pawling & Harnischfeger crane with a 5-ton auxiliary hoist will handle all heavy castings and machines in the main shop. The south wing first floor will contain the tools for manufacturing hydrants and valves, small jib cranes being provided to facilitate handling. The north wing first floor will contain the hydrant and valve assembly room and automobile and fire-fighting apparatus repair room. The second floor south wing will contain the meter shop for repairing and testing meters. The second floor of north wing is unasigned at present.

The foundry will have a capacity of 20 tons of iron and 3000 lb. of brass per day. Two outside cranes are provided, one for handling flasks in the flask storage yard,

and one for unloading and handling iron and scrap metal. Two cranes are provided in the iron foundry and one in the brass foundry. The welfare of the employees is taken care of in ample locker rooms provided with shower baths and modern lavatories.

To the north of the machine shop an administration, laboratory and garage building will be constructed. The main offices for the plant will be located in this building and 8000 sq. ft. will be assigned to the testing laboratory. The testing laboratory tests all the coal used by the city, also lubricating oils, cements, steel and any other materials entering into construction that are bought on a test basis. The garage will have a capacity of forty trucks, and will contain a vulcanizing plant and room and equipment for making repairs that do not require the machine to go to the machine shop.

POWER PLANT

Owing to the location of the plant adjacent to the city prison, and as a contagious disease hospital is being constructed on the eastern part of the new piece of property, it was decided to combine the power houses of the shops and prison and to furnish heat, light and power to all the buildings from the one plant, using prison labor for construction and to a great extent for operation. The details of this plant have not been worked out yet, but will be completed in the near future. The plant will operate as a division in city work, all departments now operating repair shops ceasing to maintain their shops. Requisitions will be made by all departments for all new work or repairs, as it is the aim to eliminate all duplicated shops and have one shop under a well-organized efficient management.

All the work, with the exception of the dock, is being done by city day labor under the direction of H. W. Clausen, engineer of water works construction, and W. H. Dean, assistant engineer in charge. The design of the buildings was made by M. B. Reynolds, engineer of waterworks design, under the immediate direction of H. S. Baker, assistant city engineer. John Ericson is city engineer in charge of all work of the Bureau of Engineering.

The total estimated cost of this complete improvement, not including the contagious disease hospital, is \$1,755,000.

ROAD PATROLMEN to the number of 116 were appointed Aug. 11 by the Pennsylvania State Highway Department.



CHARACTER OF CONSTRUCTION IS SHOWN BY THE INTERIORS OF TWO OF THE BUILDINGS OF THE NEW PLANT

Literature

For the Civil Engineer and Contractor

New Publications

EARTH WORK DIAGRAMS. By C. A. Jones. Paper; 10 x 15 in.; 5 plates and set of 60 scales for scaling quantities from a profile. Buffalo. The Yardage Scale Company, \$1.

PORTLAND CEMENT CONCRETE PAVEMENTS FOR COUNTRY ROADS. By Charles H. Moorefield and James T. Voshell, senior highway engineers. Bulletin 249, U. S. Department of Agriculture. Paper, 6 x 9 in., 34 pages; illustrated. Washington, Government Printing Office.

CHART OF EQUIVALENT UNIFORM LOADS FOR SHEAR AND MOMENT. By D. B. Steinman, C.E., Ph.D. Linen, 27 x 32 in., complete with sketches and formulas. New York, D. B. Steinman, 68 William Street, \$1.

This chart makes possible rapid computation of maximum stresses, either with or without influence lines, for all kinds of bridges designed for Cooper's live loadings. It is constructed for Cooper's E 60 loading.

GUIDEBOOK OF THE WESTERN UNITED STATES—Part A. The Northern Pacific Route with a Side Trip to Yellowstone Park. By Marius R. Campbell and others. Bulletin 611, U. S. Geological Survey. Paper, 6 x 9 in.; 212 pages, illustrated. Washington, Superintendent of Documents, \$1.

This is part A of the excellent popular guide book issued by the government and reviewed in our issue of July 17, page 85. It describes the route (by the Northern Pacific Railway) from St. Paul to Puget Sound in the State of Washington.

WIND STRESSES IN THE STEEL FRAMES of Office Buildings. By W. M. Wilson and G. A. Maney. Bulletin 80, Engineering Experiment Station, University of Illinois. Paper, 6 x 8 in., 88 pages, illustrated, tables and diagrams. Urbana, Ill., University of Illinois, Engineering Experiment Station.

Presents an accurate and an approximate method for analysis of the stresses in a steel frame due to wind pressure or horizontal shear, and compares results with four other approximate methods now in use by application to a 20-story building of three bays. The analysis is based upon assumptions which are not exactly true, but it is claimed to be more accurate than the usual methods.

Books Reviewed

Water Purification Plants and Their Operation

Author, Milton F. Stein, assistant engineer of design, Cleveland Filtration Plant. Cloth, 6 x 9 in.; 255 pages; 95 illustrations and 11 charts. New York, John Wiley & Sons, Inc. \$2.50 net.

Reviewed by Weston E. Fuller

Consulting Engineer, New York City.

In his preface the author says that his primary object in writing the book was to give instructions for the operation of purification plants. While there is much of interest to experienced operators and water engineers, the book will prove of the greatest use to the many persons who are endeavoring to operate plants under the heavy handicap of insufficient training and experience.

The book cannot be said to be in any way a complete manual, for many important matters connected with filter operation are not even mentioned. There are also many statements made with which some of the most experienced designers and operators of filters would be inclined to take exception. In his endeavors to present the subject simply the author has perhaps generalized too much and may mislead some in that way.

A considerable portion of the book is given up to descriptions of purification plants, which might, perhaps, better have

been omitted and the space devoted to operating matters. The descriptions, at the best, cover only a limited field and methods are described which are only a few of the many which are in use. A short but interesting chapter is devoted to the causes of various impurities in the water. The principal tests required in filter operation, the determination of the quantities of chemicals to be used, the methods of washing filters, the handling and application of chemicals, the keeping of records, and other matters of routine filter operation are dealt with in a simple and clear manner.

Charts to aid in making computations are also presented.

Vitrified Brick Pavements for Country Roads

Author, Vernon M. Peirce, chief of construction, and Charles H. Moorefield, senior highway engineer, U. S. Office of Public Roads. Paper, 6 x 9 in.; 38 pages, illustrated. Washington, D. C., Bulletin 246, U. S. Department of Agriculture. Copies may be had from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 10 cents.

This bulletin contains information relating to brick roads and supplies suggestions for aiding engineers in preparing specifications under which such work may be satisfactorily performed. In order that the varying physical characteristics of brick may be understood the raw materials and processes of manufacture are first discussed. Then follow sections on construction, cost and maintenance. Two appendices deal with specifications and with methods of inspection and test.

The authors deal only with sand as a cushion for the brick. In view of the increasing use of a sand and cement bed it would have added to the discussion if a few paragraphs had been devoted to this subject.

Purchasing

Author, C. S. Rindsfoos, C.E., president of the United States Purchasing Corporation. Cloth, 7 x 10 in.; 165 pages. New York, McGraw-Hill Book Company, Inc. \$2 net.

Reviewed by Elihu Cunyngnam Church

Correct purchasing is probably one of the most important business problems of the present day, and it offers many opportunities for careful study and analysis along broad scientific lines. As has been frequently pointed out in the past, purchasing is but one part of the larger question of stores control and involves the correct preparation of specifications, the exact determination of the quantities needed, and the inspection, storage, issue and use of the materials bought no less than the mere buying itself—and these are all matters so closely interrelated that no one of them can be properly considered except in its bearing on the others. Unfortunately this book does not give any attention to the larger aspects of the case. Consequently it is incomplete and not well balanced. It is a book mainly of glittering generalities. It

is loquacious, discursive and superficial. There is little in it that one can take hold of and apply in one's own business. It is a pity that when there is so much that can be written that would be new and useful that this book should be so lacking, not only in its text, but in procedure and organization charts, in diagrams, and examples of the various forms, cards, and records that would prove helpful from a statistical and accounting standpoint.

The first chapter is entitled: "How to Obtain the Right Article." In pointing out the usefulness of a knowledge of the article to be purchased we are gravely informed that "a man who is thoroughly versed in the subject of electric motors is in a better position to buy motors than the man whose knowledge is confined to dress goods, and vice versa." The second chapter relates to "price"—and other matters. It is full of such phrases as: "When the housewife instructs the greengrocer by telephone to send a dozen ears of corn and he says 'all right,' —", etc. It is too bad that the book could not have been edited before being put into type, and all the irrelevant, immaterial and inconsequential matter blue-penciled. Chapters on "Delivery," "Favorable Terms" and "Personal Characteristics and Qualifications" follow. In the latter the advice about broadmindedness is good, but, when the author, in advising the purchasing agent to be tactful, says, "This does not mean that he should be a 'mollycoddle,' nor that he should always be on the defensive. As we shall see later, it is sometimes necessary to display anger—to show one's teeth," he is silly.

It sounds strange to hear the admiration for "cunning, acumen, acuteness or shrewdness" expressed in the chapter on "Strategy" in a day when progressive business men not only refuse to stoop to their use themselves, but regard them as most undesirable characteristics in every sense of the word. "Matching wits" and much of the quibbling and bargaining advocated approaches very closely to disgraceful tactics of a variety sometimes found in a horse trade, but never in reputable business.

There is a good but brief chapter on "Some of the Legal Aspects of Purchasing"—written by another man. A chapter on "Departmental Organization" comes next, and contains many positive assertions that are open to question, for instance, the statement that "the storehouses and materials therein should be under the accounting department or else under whatever department will use the stores." Now, at the present time, most men agree absolutely that, except in small quantities, supplies should never be in the custody of the men who use them. Here also is reprinted in part the report which Comptroller Prendergast made to the New York Board of Estimate a few years ago concerning his proposed plan for the central purchase and distribution of supplies for the city.

The latter part of the chapter is taken up in amplifying the statement that: "The author believes there are many reasons why the ideal purchasing department of the not far distant future will be in the form of a separate company." Incidentally the author is president of such a company himself. Q.E.D.

The book ends with some fifty odd pages of so-called forms or form letters running all the way from a simple letter asking for a bid to a blank form of agreement to buy real estate.

HINTS FOR THE CONTRACTOR

Details Which Save Time and Labor on Construction Work

Other articles in this issue of interest to contractors and construction engineers are indexed in the Table of Contents

[Contributions to this section are solicited, and if found available will be paid for. They must be SHORT, and should be accompanied, if possible, by photographs or sketches.—EDITOR.]

Excavator Hitches to Its Own Platform to Move Over Soft Ground

TO MOVE a dragline excavator over soft material where the bucket would not hold, the Winnipeg Aqueduct Construction Company turned the machine around, hitched the bucket to a chain run through the bed of the excavator and fastened to the front edge of the advance platform section, and moved the excavator by backing it up. According to the *Excavating Engineer*, the machines that were moved in this fashion were being operated in muskeg swamps. To pull them ahead in the usual way by casting the bucket out in front of the machine required digging away 4 to 6 ft. of this soft vegetable mold before the underlying clay, in which the bucket could get a firm hold, was reached. In principle the method is the same as that often employed to move traveler derricks, where the load line is attached to the track, and the engineer booms down and picks up his load, backing up the traveler. In each case the weight on the track or platform of the rig being moved furnishes sufficient anchorage to hold the pull needed to make the move.

Wire Rope Clips Should Be Put On with Saddle Next Main Part

IN CLAMPING the end of a wire rope around a thimble all the clips used should be put on with the saddle next the main part of the rope. The obvious reason for this is that the saddle of the clip develops a much better grip on the rope than does the U-bolt. Most of the strain in a fastening of this kind is on the main part of the rope, and very little pull exists in the end part. If the saddle of the clip is clamped against the main part, the clip holds this part against sliding past the saddle and past the rough surface of the other part. If the clip is reversed, its grip on the main part of rope is reduced to the friction of the main part against the end part of the rope, and to the grip of the U-bolt on the main part. This grip is comparatively slight unless the clamp is tightened so much as to flatten the strands of the rope.

Users of Hercules wire rope have recently been advised of a convenient way of making an eye at the end of the rope. The length of the end beyond the center of the eye is determined by the number of clips required by the load, allowing several inches to each clip. This length is measured back from the end of the rope, and the round part of the thimble is tied to the rope at this point with wire. The rope is then bent around the thimble and tied at the point of the thimble with another wire. The first clip put on is the one farthest from the eye. This is tightened, and the other clips required put on loosely. A strain is then taken on the rope, which equalizes the rope

around the eye, before the remaining clips are tightened up. It is bad practice to tighten a clip entirely with one nut. This twists the grip of the clip on the cable, and is liable to bend the clip and make it worthless. The nuts should be screwed up a few turns at a time alternately. After a rope has been in use a short while, it is necessary to go over all the clips and tighten them up. As strain on the rope pulls it out straight and slightly reduces its diameter, serious trouble has been caused by the clips becoming loose and slipping when this precaution has been neglected.

Nearness of Railway Tracks Aids Concreting of Retaining Walls

By KENNETH C. CARDWELL
Cincinnati, Ohio

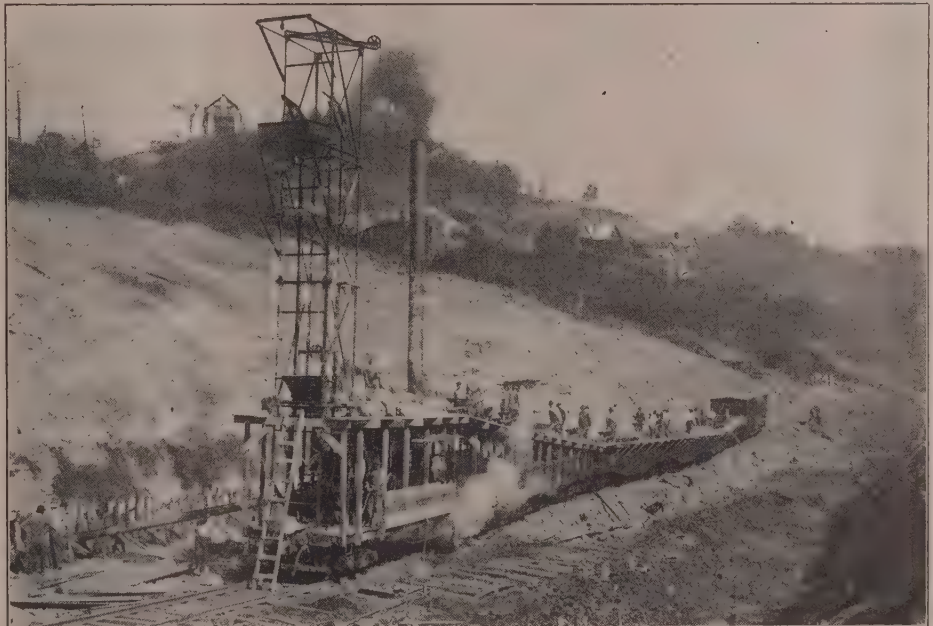
GOOD use was made of the proximity of railroad tracks by the Marquette Construction Company of Chicago, in handling concrete, materials, and equipment for the

which the material-handling plan, involving the use of the tracks and of the cars containing the materials, was carried out.

The typical layout of the equipment used for any given piece of concrete work on this job consisted of two ordinary gondola cars bearing the concrete machinery and a sloping platform leading from other cars in the rear. The rear cars included a car of gravel, three cars of sand, and, at the extreme end of the row, a car of cement in sacks. The two front cars, besides bearing the platform and equipment described, were also used for storing coal and miscellaneous supplies, such as shovels and wheelbarrows.

TOWER FOR CONCRETE DISTRIBUTION

The concreting equipment consisted of a steel tower built at the extreme end of the foremost car, 30 ft. in height above the floor of the car, and a mixer of 1-yd. capacity, with a 42-hp. engine to operate it. The tower was used in handling concrete to be placed at comparatively distant points. All of this equipment, excepting, of course,



RUNWAYS BRACKETED OUTSIDE CARS OF MIXER TRAIN ON RAILROAD WORK

heavy concrete walls of the underpass and track-supports required in separating the grades of Eastern Avenue, Cincinnati, and the Pennsylvania railroad tracks, which parallel them for a considerable distance. Practically the same mixing equipment was used for the entire job.

The work in question was in progress for about a year. A great part of the time consumed was required by the large amount of excavation and filling necessary, the placing of the concrete by the use of the equipment and methods referred to being in all cases comparatively rapid after the preparation of the grade. The cost of the work, about \$500,000, was shared by the railroad company and the city. Undoubtedly, the co-operation of the railroad company, by reason of its immediate concern in the work, contributed largely to the facility with

the tower, was covered over with the platform referred to, which was built over the two front cars, of 2 x 6-in. lumber, to a width of 12 ft. The photograph indicates the height to which the platform rose at the end of the front car, only the smoke-stack appearing above it.

RUNWAYS HUNG OUTSIDE OF CARS

The hopper of the mixer was set in this platform, flush with the surface, and immediately under a metal water-tank. This tank had sufficient capacity for a maximum batch of concrete, with an automatic device to measure the water. A tender at the hopper operated the tank and also took care of the cut-off which regulated the admission of the materials to the mixer.

The platform over the two front cars, level at its higher end, sloped down a length

of about 80 ft. to the material cars behind. Running along both sides of these cars, and forming a smooth connection with the platform, were movable running-boards for the use of the men wheeling material up to the mixer. These running boards were each built up of a pair of 2 x 12-in. boards, upon 2 x 6-in. pieces as a framework. The framework was so arranged, with heavy cleats, as to enable the complete running-boards to be hung on the sides of the cars, firmly supported by their own weight against the cleats and the car structure.

This method of supporting the running-boards, by cleating to the sides of the gondola cars containing the sand and gravel, was, of course, impracticable for use with the box-car in which the cement was loaded, and the boards were therefore supported to the door of this car on trestles.

SIXTEEN MEN IN WHEELBARROW CREW

A crew of sixteen men, with wheelbarrows, was used to keep the material moving, eight men moving down on each side in turn; and several men in each material car shoveled the sand and gravel into the barrows as they were wheeled down empty. As these two strings of eight wheelbarrows each came down alternatively, no congestion occurred either at the cars or at the mixer. The men in the cars were kept shoveling, while the mixer was supplied regularly with the required material for the batch.

All of the concrete placed was in mass, the construction being very heavy retaining walls. A 1:2:5 mixture was used throughout. The number of material cars placed in the working train at any one time, therefore, was regulated by this fact, and usually worked out very accurately, the hand and gravel cars being emptied very nearly at the same time. It was not possible, however, to regulate the supply of cement this closely, as it was necessary to use the box-cars in which it was shipped in order to protect it from the weather, and the relative capacity of the cars could not be worked out as nicely with a box-car as with the gondolas. The value and availability of railroad co-operation was fully utilized by Superintendent J. J. Casey, who was in charge of the work, and there was the least possible delay between the arrival of a car of material and its use in the mixing of concrete and placing in the work. A large part of the work being close to the tracks, the use of the tower on the front car was not always necessary, chutes direct from the mixer being employed satisfactorily. When the tower was used the concrete was dumped from the mixer into a bucket on the tower, hoisted by a cable connected with the engine, and emptied in the usual manner into the steel chutes.

Safety First in Road Building

THAT THE RECENT improvements in tools and methods on road construction have not resulted in any corresponding increase in the safety of the workman engaged in this class of construction is forcibly brought out in the *Travelers' Standard* for August. Accident prevention is of the greatest importance to road contractors, as well as to others. It is well recognized that freedom from accidents, aside from the money saving and reduced premiums, enables the contractor to build up an organization that is more efficient because it has confidence in itself and in the

construction methods that are being used.

One of the principle sources of accidents on road work—and many of them are fatal—is blasting. Dynamite requires extreme care in handling, and should be placed in the exclusive charge of a safe and competent man. This man should see that the charges are of the proper size, and that fuses and caps, or blasting machines and wiring, are in first-class condition. The foreman should select a place of safety and see that all the workmen reach it before allowing the blast to be fired. Men should be assigned to warn persons passing near the work. Heavy rope mats and logs bound together by chains are absolutely necessary to prevent flying debris in work near cities and towns, and their use often pays in more open country. In one instance, a man standing in his own yard a quarter of a mile from where blasting was being done on road work without such a mat was struck by a small piece of rock and instantly killed.

The most serious accidents are often caused by men returning to work too soon after a misfire. Numerous cases have demonstrated that, where fuses are used, it is not safe to venture near a misfire for several hours. In one instance several workmen were killed by a blast fired with a defective fuse which did not go off for half an hour after it had been decided that all danger was over, and the men had been sent back to work.

Felling trees in clearing for road work is another fruitful source of accident, and this work should be done carefully by experienced men. Constant vigilance must be employed to prevent accidents from landslides in making cuts for road work. Especially is this true where men work on the top edge of the cut.

Care should be exercised by men working around a steam shovel, and the foreman should see to it that the men keep in the clear, and that the shovel is properly handled and kept on a solid foundation. Many wagon drivers become too lazy or careless to get down from their seat while their carts are being loaded. Drivers should be compelled to do this by the foreman; if they remain in their seats, they are in danger of being struck by material falling from the dipper, or of being brushed off by the dipper itself.

Handling the materials used in road making is also a prolific source of accident. Caution should always be exercised to pile cement bags, paving blocks and other material solidly so that they will not fall over and injure some one. Loading and unloading oil barrels and other heavy objects should not be attempted with a green crew, as lack of co-operation by the men, or the misunderstanding of an order is almost certain to result in the injury of some one.

Many accidents are reported each year from over-crowding of the men at work, or from the carelessness of the men where there is plenty of room. The men will always go to the point indicated by the foreman, and will crowd themselves together without regard to the danger of striking each other, if they think they have been ordered to do so. It is well-known that the man in charge can get more work out of his men by placing them so that they will not interfere with one another, and care should always be taken to see that this is done.

Many accidents have been caused by reckless automobile drivers rushing at high speed past points where road work is going

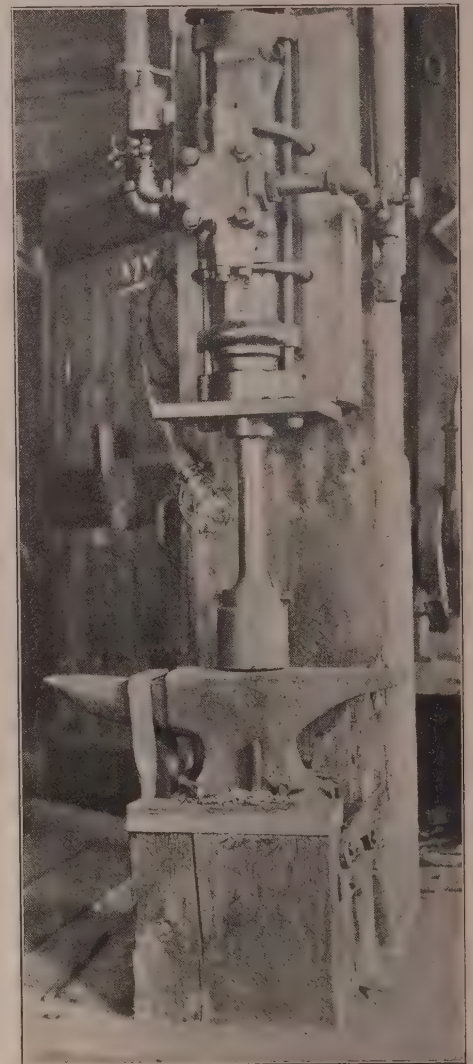
on, and either striking some of the workmen or throwing in the air tools that have been left in the roadway. The roadway should at all times be kept clear, and the Travelers Insurance Company suggests that contractors who suffer from the acts of drivers of this class erect solid barriers at each end of their work, forcing such men to come to a dead stop before they are allowed to proceed.

Air Drill Does Duty as "Steam" Hammer in Blacksmith Shop

By WALTER BAZORE

Master Mechanic, Rapid Transit Subway Construction Company, New York City

BY REMOVING the rotating pawls and bratchets from the air drill shown in the accompanying photograph and clamping a heavy ram in the drill chuck it was con-



AIR DRILL AS BLACKSMITH'S HAMMER

verted into a power hammer for a contractor's blacksmith shop. Before being used for this purpose the drill had been mounted in a frame of steel rods, with its rotation removed and a rod, with a dolly-plate welded to its lower end, inserted in the chuck, and used as an air hammer for driving sheeting.

This hammer, made by the writer, is in the blacksmith shop of the Rapid Transit Subway Construction Company's power plant at Forty-second Street and East River, New York City.



1.—THE STRUCTURE THAT SAVED GALVESTON FROM THE SEA'S TERRIFIC ONSLAUGHT—THIS VIEW OF THE SEA-WALL, TAKEN AFTER THE STORM, INDICATES HOW WELL IT SURVIVED THE ORDEAL OF AUGUST 17

Galveston's Sea-Wall Checks Hurricane's Devastation

Concrete Structure Along Waterfront Saves Texas City from Repetition of Catastrophe of 1900, Although Damage Done Is Severe—Causeway Approaches Demolished—Water Supply Cut Off—Houston Also Suffers

By E. B. VAN DE GREYN

Consulting Engineer, Houston, Texas

THE sea-wall at Galveston, Tex., was the city's salvation during the hurricane of Aug. 16-17. This is the outstanding feature, from the engineering viewpoint, of the effect of the recent storm, which rivalled in intensity, but not in loss of life and damage to property, the one of 1900. But while the concrete works which flank the waterfront did noble service the city suffered considerable damage. The causeway, the 2-mile concrete viaduct which links the island city with the mainland, suffered heavily, its earth embankment approaches having been washed out, although the concrete arches forming the central portion of the structure withstood the impact of huge waves, lashed into fury by a 90-mile-an-hour gale. The city's water supply was cut off by the breaking of the pipeline across the bay and the demolition of

frame houses within striking distance of the sea was general, although none of the city's more substantial buildings was wrecked. The pavement back of the sea-wall was badly scoured and one wharf was destroyed.

WIND VELOCITY 100 MILES PER HOUR

A trip through Galveston gives one some idea of the power of the storm. The effects of wind and water are shown in the accompanying pictures. The storm center swept 25 miles to the west of Galveston and passed west of and closer to Houston on its way north. The Weather Bureau at Galveston gave out the following information: The velocity of wind passed 32 miles per hour at 4 a. m. Monday, Aug. 16. From 3 p. m. Monday until 10 a. m. Tuesday it blew 60 miles per hour or more. The maximum velocity for 5 min. was 93 miles per hour,

occurring at 2.37 a. m. Tuesday, Aug. 17. During that period the records show a velocity of 120 miles per hour, lasting 30 sec.; in many of the gusts 100 miles per hour was reached. The lowest barometric reading was 28.6 in. at 2.40 a. m. Tuesday, Aug. 17. On Tuesday, midnight to midnight, 9.05 in. rain fell. At about 2 p. m. Monday the direction of wind began to shift from north to east and to south, being east at 3 a. m., Aug. 17.

SEA-WALL INTACT

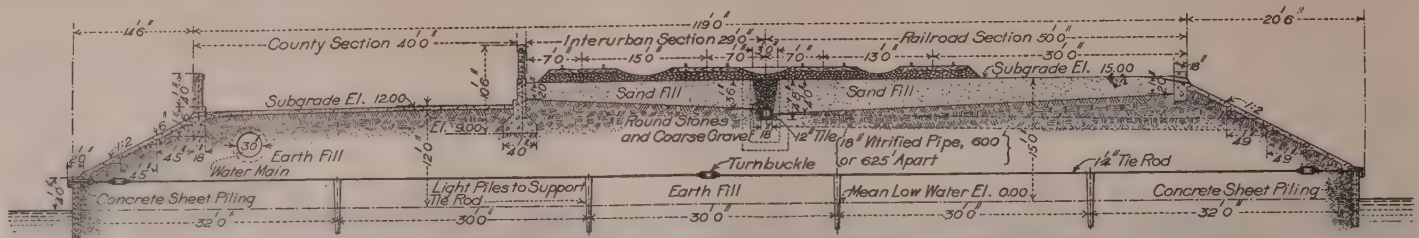
A general view of the situation at Galveston may thus be stated: The sea-wall held intact throughout and undoubtedly saved the city and vindicated the confidence of Galveston people in the wall. The causeway suffered heavily, the only portions left intact being the movable span at the



2.—THE BOULEVARD PAVEMENT BACK OF THE SEA-WALL WAS WASHED OUT BY WATER BLOWN INLAND BY WIND



3.—IN ONE PLACE THE UNDERMINED BRICK PAVEMENT HUNG AS A CANTILEVER 9½ FEET LONG



4.—SECTION OF EARTH EMBANKMENT APPROACH TO GALVESTON CAUSEWAY WHICH SUFFERED HEAVY DAMAGE

center, the concrete arches on each side of span and a portion of about 2000 ft. at the southerly end of the protected approach at the Galveston end.

The water supply of the city from Alta Loma is cut off by a break in the submerged pipe line crossing the bay west of the causeway. The docks and wharves and elevators might be considered to be damaged to a minor extent compared to other damages. Some docks have only had a few planks ripped off. The conveyors from some elevators were destroyed. One or two piers were reported destroyed.

the city was unprotected from the onslaught from the Gulf and the less substantial frame houses were swept entirely away.

The sea-wall, built in 1903, is $3\frac{1}{2}$ miles long and is of concrete reinforced with $1\frac{1}{4}$ in. steel rods as shown in the cross-section on page 274. The concrete is carried by a wood pile foundation and the outer or exposed face is curved to throw the sea vertically upward. The concrete base is 3 ft. thick and the wall proper rises 13 ft., giving a total height of 16 ft. to the concrete work. The toe of the wall is protected by a mass of heavy granite rip-rap

into the air and the wind would then throw the sheet of water onto the pavement behind the wall. Photograph 1 shows the concrete walk and brick pavement back of wall uninjured. The piling at the left is the remains of the bath-houses. In front of the buildings on the left two cubical granite blocks, each 4 ft. on a side, were moved about 70 ft. by water and wind. Photos 2 and 3 show where the water washed out the pavement and walk back of sea-wall. The fill under these pavements was of sand. The boulevard walk and pavement were washed out from about Seventh Street westerly for



5.—THE CENTRAL PORTION OF THE CAUSEWAY, CONSISTING OF CONCRETE ARCHES, WAS PRACTICALLY UNINJURED

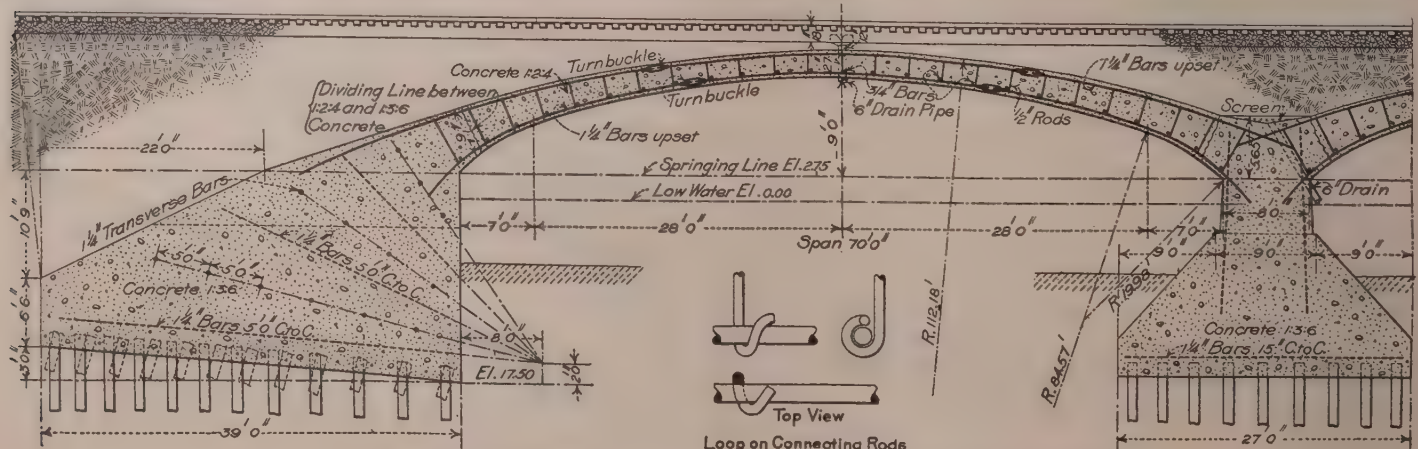
A very great damage resulted from the water rising up in the stores in the business section and ruining the goods within. The height of the water in the city, as reported by different persons who were there in 1900, places it at from 6 in. to 2 ft. higher than in 1900.

In general the frame houses along the sea-wall boulevard facing the beach and for a little distance back were demolished or overturned. Substantial structures like the Galves Hotel were apparently uninjured, except for roofing metal torn off by the wind. Beyond the westerly end of the sea-wall

and the wall itself is backed by an earth fill brought to the level of the top of the wall and formed into a driveway about 70 ft. wide. The wall was designed by George W. Boschke of Galveston, and built by J. M. O'Rourke & Company of Denver, Col., whose contract price was \$1,198,000. The sea-wall was described in the Engineering Record of July 4, 1903, page 14, and the causeway in the issues of Oct. 15, 1910, May 27, 1911 and July 13, 1912.

An eyewitness at the sea-wall during the storm stated that the curved face of the wall caused the water to shoot straight

ten blocks and from Thirty-eighth Street westerly along practically the entire length of the military reservation to the westerly end of sea-wall. The break at Thirty-eighth Street was probably caused by the pounding of a three-masted schooner which broke against the wall at that point and pounded to pieces. In some places where the pavement was washed away the sand backing was washed 7 to 9 ft. below the top of the wall. In many cases the $3\frac{1}{2}$ -in. brick pavement overhung 4 to 5 ft. and in one place it overhung as a cantilever $9\frac{1}{2}$ ft. Along the military reservation much of the



6.—TYPICAL SECTION OF CAUSEWAY ARCH CONSTRUCTION WHICH SURVIVED STORM'S FURY

Causeway Approaches Were Galveston's Greatest Storm Loss



7.—DEMOLITION OF CAUSEWAY EMBANKMENT WAS COMPLETE—VIEW TAKEN LOOKING NORTH TOWARD MAINLAND, SHOWING, NEAR TOP CENTER, OVERTURNED STREET RAILWAY CAR



8.—ANOTHER PICTURE OF CAUSEWAY APPROACH—THE CONCRETE SLABS WHICH COVERED THE SLOPES WERE DISPLACED BY WAVES BUT THE SHEET PILING RETAINING STRUCTURE HELD



9.—FIRST BREAK IN CONCRETE SLAB SLOPE PROTECTION ON CAUSEWAY



10.—PARAPET WALLS UNDERMINED

smaller rip-rap was tossed from the toe of the wall up and over top of wall to a distance of 50 ft. One such stone measured $4 \times 2\frac{1}{2} \times 1$ ft.

Photo 11 shows how the storm treated some of the cottages and small frame houses near the sea-wall boulevard. Where the sand was scoured out behind the sea-wall it was carried inland for some distance covering fences and car tracks.

The sea-wall itself was not injured seriously at any point along its length. That it saved the city great damage, if not destruction, is sure. Beyond its westerly end where there was no obstruction to the force of the waves the country was swept clean of the frame houses which occupied that section.



11.—FRAME HOUSES ALONG WATERFRONT WERE TOSSED LIKE JACK-STRAWS INTO A TUMBLED HEAP, BUT CITY'S LARGE BUILDINGS STOOD UP

APPROACHES TO CAUSEWAY WASHED OUT

The moveable span of the causeway and the concrete arches at each end of the span are intact. The north protected fill approach is demolished except for the toe walls on each side at the foot of the slopes, the toe walls being concrete sheet piling with concrete cap cast on top of piling. The south protected fill approach also is demolished except for about 2300 ft. at the south end, which is partly destroyed.

Photo 7 was taken at the north end of the arches looking north to the mainland.

the first break, about 100 ft. long, in the concrete slab slope on the west side of the south approach. This break occurred about 850 ft. from the island end. Photo 10 shows where water coming over the top of the causeway would dig a hole and undermine the parapet wall and slabs, opening up a breach for the water to finish the work of destruction. Very probably it was in this way that the destruction of the approaches started and progressed to completion.

Attention should be brought to the fact that the concrete slabs on the east side of the remaining part of the south approach were displaced. This is the side of the structure occupied by the steam lines. If the breaks in the approaches started as indicated above, as seems entirely reasonable, then it is probable that the causeway would not have been injured if the roadway surfaces, etc., on top had been impervious.

WATER SUPPLY CUT OFF

The main bringing water to Galveston from Alta Loma was discovered to have a break where it is submerged near the causeway. The work of repairing this break or of working out the proper solution to bring the water to Galveston was

work in getting connections for transportation between the mainland and the island. A single track temporary trestle is to be built as rapidly as is possible.

STORM'S AFTERMATH AT HOUSTON

Considerable damage resulted in Houston from the wind of the hurricane. When more reports are available it will in all probability be shown that the center of the storm passed near Houston. The storm struck Houston Monday night, Aug. 16, and on Tuesday morning the lowest barometer reading was 28.21 in. at 4.30 a. m. The velocity of the wind passed 32 miles per hour at 6 p. m. Monday. The instrument did not register from 4.35 a. m. to 5.55 a. m. Tuesday and the maximum velocity was probably not recorded. When a new instrument was put in at 5.55 a. m. Tuesday it recorded a maximum velocity of 80 miles per hour for 5 min. A velocity of 105 miles per hour lasting about 40 sec. was recorded. The total rainfall from noon Monday, Aug. 16, until 5.40 a. m. of Aug. 19 was 9.08 in. Wires were down Tuesday and no trains ran on that day. The city was completely isolated. With wires going down power and electric light were cut.

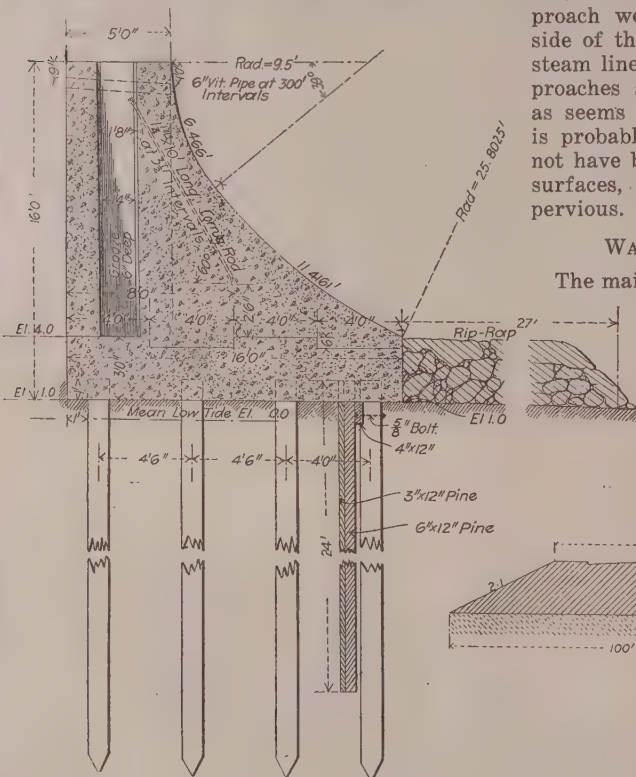
In the downtown section the damage consisted of plate glass windows breaking, signs, awnings and similar protections being blown down. Stocks of goods in show windows were of course damaged. Many tin roofs peeled and were rolled up and dropped onto the street below. In the residence sections the greater part of damage consisted of broken windows, uprooted or broken trees, fences blown down, and the collapse of flimsy shacks. A brick church was partly demolished. All buildings which were at all substantially built stood the shock of the storm, but light, unbraced construction was blown down by the wind as might be well anticipated.

At the present writing conditions in the business sections appear normal and have little appearance of having passed through a storm. Street car service, etc., is established, also train service, etc.

How STORM DATA WERE SECURED

[With Mr. Van de Greyn's article on the Galveston storm was received a letter, dated Aug. 22, in which he described some of the difficulties encountered in getting the facts for his story. While it treats of conditions of no particular technical interest it pictures so clearly the human side of a great disaster that it is published in part below.—Editor.]

"Train service is still demoralized in certain quarters. Galveston and Texas City, through which I had to go to get boat to



12.—SECTION OF SEA-WALL WHICH GALVESTON CAN THANK FOR PREVENTING A REPE- TITION OF THE STORM DAMAGE OF 1900

This view shows practically utter destruction of the approach. In the foreground is an interurban car which was marooned on the causeway. The passengers escaped. On each side can be seen many of the concrete slabs which protected the slopes of the fill from wash and which are lying on the concrete lap of the sheet piling toe wall.

Photo 8 shows the section of the south protected fill approach destroyed.

Since it would be of interest to attempt to figure out how the destruction of the approaches began, photos 9 and 10 are shown as especially important. Photo 9 shows

placed in the hands of the railway engineers. In the meantime drinking water was being distributed in city sprinklers from the supply that was on hand within the city. Some water is supplied by an artesian well and cistern water is being used.

The merchants are busy cleaning out their stores and citizens are at work on repairs. The city is well policed by soldiers and civilians.

Telegraph and telephone connection was re-established into Galveston Friday night, Aug. 20. The steam line and electric line engineers are busy planning and starting

Galveston, have been under martial law. I had no time before leaving Houston to get a permit from the Mayor of Houston to pass me through, but I managed to slip through with two other people who had permits.

"Went by auto from Houston to Texas City, where martial law prevails, as that place was badly swept by water. Dead cattle are lying all about and are being burned by soldiers after crude oil was run over land. Got to Galveston by boat from Texas City, arriving there about 10 p. m.

"Found Galveston lighted by lanterns and candles and soldier guards at almost every corner. There had been trouble I was told from niggers looting show cases, etc., and some had been shot—you can believe only what you see yourself in many things during these times. Found hotels full, with no running water for washing. Did not wash until I returned to Houston. Some intelligent people were somewhat alarmed for fear of typhoid breaking out. There is of course that danger, but the authorities are getting matters in hand and will, I think, keep down any outbreak—these things are not for publication, as citizens would resent any talk likely to hurt the city.

"Up to date there has been sufficient water and the prices of foodstuffs at restaurants are the same as during normal times. The greatest concern of the city of Galveston at the present time is to get its water connection with Alta Loma hooked up. I. J. Cottingham of the S. P. R. R. has taken charge, on request of the city, of getting the water connected. While I was at the causeway yesterday he was on a boat with divers and had located one end of the broken water main and was trying to locate rest of trouble. As I did not get to his boat to see him personally I cannot speak with much authority on exactly what was found, or exact plans.

"After getting pictures of the sea-wall I found it possible to get only within about 2 or 3 miles of causeway and was informed that permit from Mayor Fisher was necessary to pass guards. So trip was made back to town for permit and after securing that I went back and then walked to the causeway. The walking was bad since the road and tracks leading to causeway for 2 or 3 miles were badly damaged by the storm, and pole lines of all kinds were down. After taking pictures at causeway and examining situation I made my way across to mainland and got back into Houston finally.

"It seems certain to me and others that if there had been an impervious pavement covering the top surface of the roadways the approaches would not have been demolished, as it seems evident that the destruction started by the water gouging out the filling between the parapets.

"As regards the sea-wall it certainly demonstrated its strength since the pavement and sand were washed out for long stretches behind the wall to depths ranging from 3 to 9 ft. below top of wall and wall was subjected to hard hammering. For example where a three-masted schooner hit wall and battered itself to pieces the wall must have been subjected to terrific blows. This boat hit the wall at easterly end of the military reservation and all I could see left there were spars, etc. Sergeant who escorted me about reservation told me that a sergeant and two corporals rescued captain of vessel who was lashed to wheel and had both legs broken. He was still alive, but uncon-

scious. Whether he has recovered I could not find out. One reliable person said the captain could still lie since he stated that where it took him ordinarily two days to get out to sea he came back in 45 min. in the gale to the sea-wall.

"I was told that one of the piers was destroyed and that other piers were damaged little. The piers I saw had only a few planks ripped off. The new Southern Pacific elevator was uninjured, according to all reports."

Meteorological Analysis of Storm Indicates Similarity to Hurricane of 1900

Disturbances First Noted in Barbados—Track of Storm Crosses Gulf Following Route Taken 15 Years Ago—Weather Bureau Active in Sending Out Warnings

THROUGH the courtesy of C. F. Marvin, chief of the U. S. Weather Bureau, the Engineering Record is enabled to present the following report on the tropical storm of Aug. 10-23, prepared by Prof. H. C. Frankenfield, the forecaster on duty at the time:

The tropical storm of Aug. 10-23, 1915, was the first great tropical storm to visit the Texas coast since the equally famous storm of Sept. 1-8, 1900. It first came within the field of observation on the morning of Tuesday, Aug. 10, when the barometer at Bridgetown, Barbados, and at Ros-

have occurred with much lower pressure. During the next 24 hr. the storm passed over, or very near, the eastern portion of the island of Jamaica, and on the morning of Aug. 13 it was central a short distance to the northwest of that island at about latitude 19 deg., longitude 79 deg. On the morning of Aug. 14 the storm was over extreme western Cuba, moving a little more north of west. Havana reported a barometer of 29.72 in., with a maximum wind velocity of 56 miles an hour from the east. By this time the wind had reached 38 miles an hour from the east at Key West, and a radio report from a vessel only a short distance southwest of Key West reported a wind of 65 miles an hour from the east. During Aug. 14, as the storm center passed over extreme western Cuba, a wind velocity of 68 miles an hour from the northeast was reported from Pinar del Rio and the meteorological station at Cape San Antonio, Cuba, was put out of commission owing to the destruction of the radio apparatus.

On the morning of Aug. 15 the storm center was in southeastern Gulf of Mexico, at about latitude 23 deg., longitude 89 deg. This location was determined largely from radio reports from the east and northeast Gulf. The storm was now moving in a northwesterly direction, and at 8 p. m. of Aug. 15 a radio report from latitude 26.5 deg. and longitude 88 deg. reported a barometer reading of 29.48 in. and a wind velocity of 64 miles an hour from the east. A radio report at noon of the same day at latitude 27 deg. longitude 86 deg., gave a barometer reading of 29.54 in. and a wind velocity of 74 miles an hour from the east. On the morning of Aug. 16 the storm center was apparently at about latitude 26.5 deg., longitude 93 deg., and during the night moderate east and southeast gales had occurred on the middle Gulf coast with tides from 1 to 2 ft. above normal. At the same time the barometer reading at Galveston was 29.62 in., with a maximum wind velocity of 38 miles an hour from the northeast. Very rough seas were reported at Gulf stations west of Mobile.

HURRICANE REACHES GALVESTON

TRACK OF THE HURRICANE WHICH STRUCK GALVESTON AUGUST 17

It followed almost the same course as the storm of 1900. The figures on the path lines indicate dates of month for August, 1915, and September, 1900.

eau, Dominica, read 29.80 in., a fall of 0.14 in. in 24 hr. On the morning of Aug. 11, the storm center was apparently south of the island of St. Croix, at about latitude 16 deg. N, longitude 66 deg. W.

The lowest barometer reported during the first 24 hr. of the storm was 29.46 in. at Roseau, Dominica, at 4 p. m., Aug. 10. On the morning of Aug. 11 the lowest barometer reported was 29.76 in. at San Juan, P. R., with a wind blowing 60 miles an hour from the northeast, indicating a much lower barometer reading to the southward. On the morning of Aug. 12 the storm was central a short distance south of Haiti. The barometer reading at Port au Prince, Haiti, at that time was 29.60 in. The highest wind velocity reported at Port au Prince was 32 miles an hour from the east, but according to the reports of damage over the lower portion of the republic a severe gale must



During the night of Aug. 16-17 the storm passed into Texas just south of Galveston, and at 2.45 a. m. of Aug. 17 the barometer reading at that station was 28.63 in.—0.21 in. higher than the lowest reading during the storm of 1900. The maximum wind velocity was 93 miles an hour from the east at 2.37 a. m. and the tide was 6 in. higher than that during the 1900 storm. The hurricane winds continued for 19 hr. at Galveston. At 5.30 a. m. of Aug. 17 the barometer reading at Houston was 28.21 in.—0.21 in. lower than any reading reported during the storm of 1900—and the wind blew at the rate of 80 miles an hour from the southeast and northeast. At 8 a. m. of Aug. 17 the

storm was central a short distance west of Houston with a tendency toward a more northerly direction. The storm now moved northward with steadily decreasing intensity, and on the morning of Aug. 18 it was central over the central portion of east Texas with a barometer reading of 29.50 in. or a little lower. There was then a recurve to the northeastward, with a slow velocity of progression, and on the morning of Aug. 19 the storm was central over the northeast portion of east Texas, with a barometer of 29.58 in. at Dallas.

During the night of Aug. 19-20 the storm again began to increase in intensity, with a northeastward movement, and on the morning of Aug. 20 it was central over southeast Missouri with a barometer reading of 29.42 in. at Cairo, Ill., and with a wind from the southeast. At 8 p. m., Aug. 20, the barometer reading at Evansville, Ind., was 29.40 in., and on the morning of Aug. 21 the storm was central over Indiana, with a barometer reading of 29.52 in.

TORRENTIAL RAINFALL

The rainfall accompanying the storm was torrential over east Texas, northwest Louisiana, Arkansas, east and south Missouri, and southern Illinois. Complete reports of precipitation from Texas stations are not yet available, but the total fall during the storm probably ranged between 5 and 15 in. At St. Louis the rainfall for the 24 hr. ending at 8 p. m., Aug. 20, was 7 in., and moderate gales occurred over east Missouri, the lower Ohio valley, and west Tennessee. There were also severe northerly gales over the interior of east Texas on Aug. 17, the wind velocities ranging from 44 to 60 miles an hour, the latter at San Antonio.

In the vicinities of Galveston and Houston, and from thence northward, enormous losses were reported, some of the figures reaching as high as \$60,000,000, of which \$40,000,000 was in crops. These figures, however, must be a gross exaggeration. Another result of the storm was the floods in the Texas and Arkansas, and the middle Mississippi rivers. These, however, do not promise to become of great importance, except in the White River of Arkansas.

TRACK OF STORM FOLLOWS COURSE OF HURRICANE OF 1900

The track of the storm is shown in the chart herewith and there is also included the track of the storm of September, 1900. It will be seen that the two tracks are very similar as a whole and, so far as can be determined at present, the storms were of about equal intensity. The highest 5-min. velocity at Galveston during the 1900 storm was 84 miles an hour, while during the 1915 storm it was 93 miles an hour. However, during the 1900 storm the anemometer blew away immediately after the wind reached the velocity of 84 miles an hour, and the official in charge of the Weather Bureau station estimated that the wind later reached a velocity of 120 miles an hour.

WEATHER BUREAU'S WARNINGS

The first warnings were issued by the U. S. Weather Bureau at 9.45 a. m., Aug. 10, when the storm was noted near the island of Martinique, and they were issued regularly thereafter to all ports on the Atlantic and Gulf coasts and distributed by radio from Arlington and Key West twice or thrice daily.

On the morning of Sunday, Aug. 15,

northeast storm warnings were ordered on the Gulf coast from New Orleans to Apalachicola, Fla., and at 5 p. m. warnings were changed to hurricane at New Orleans, and hurricane warnings were also ordered displayed at all places from New Orleans to Brownsville, Tex. These warnings were continued at 5 p. m., Aug. 16, for another 24 hr. An inspection of the charts in connection with this statement will indicate the accuracy of the warnings so far as the direction and movement of the storm were concerned.

MOTOR-CYCLISTS SPREAD ALARM

During the storm of 1900 it was estimated that over 6000 persons lost their lives at Galveston and vicinity, and that this horror was not repeated during the present storm was undoubtedly due to the magnificent sea-wall erected by the citizens of Galveston shortly after the storm of 1900, as well as to the fact that the heaviest winds in 1915 did not come directly from the south or Gulf quarter as they did in 1900. It should be added also that the personal efforts of W. P. Stewart, in charge of the local office at Galveston, Tex., certainly saved the lives of many of the residents of Galveston Island. Mr. Stewart upon receipt of the first warnings sent out men on motorcycles to all parties that could be reached on the island within a radius of 30 miles from the city. These persons were warned that unless they immediately left for places of safety they would surely lose their lives. From press despatches it is apparent that hundreds of lives were saved by these warnings.

John B. Hawley Confirms View That Sea-Wall Saved Galveston

THE following telegram was received from John B. Hawley, consulting engineer, of Fort Worth, Tex.:

"The city of Galveston was saved on Aug. 16 and 17 by a concrete sea-wall that encircles the city Gulf front. This wall was built after the 1900 storm as a protection against the Gulf waves, and has fulfilled its mission. In the whole structure there is not a single break. The sea-wall has reduced the storm loss to a minimum.

"To the United States Weather Bureau is due great credit for their warnings. The loss of life in the city, back of the sea-wall was less than a dozen, mostly people who in attempting to get to places of safety were either drowned or struck down by flying missiles. The loss of life in the bay, and in the small towns unprotected on the mainland will aggregate not to exceed 100.

"The property loss has been variously estimated. Mayor Lewis Fisher, in a statement to the press, estimates the damage to property at \$2,500,000. The loss has been variously estimated from the mayor's figures up to \$10,000,000. The heaviest loss is in the causeway that connects Galveston Island with the mainland. This was partly demolished during the storm and railroad and interurban traffic cannot be resumed until temporary structures on which work is now progressing are serviceable. Individual losses were sustained by many persons who owned cottages and bungalows near the Gulf front. Back of the sea-wall the loss to merchants in salt-water damage to stocks is also large.

"The city was without water for several days after the storm, owing to the destruc-

tion of the pipes across the bay. A temporary system of piping the water from the city plant several miles up the mainland has been built, and is now in use pending the reconstruction of the main pipe line.

"Galveston citizens on the day after the storm announced that no outside relief would be necessary. A central committee composed of representatives of business, labor and religious organizations are furnishing temporary relief in all cases."

Builders of the Causeway Tell of the Storm's Effect

FURTHER information as to the damage to the causeway is contained in the following extracts from a letter received from the Blodgett Construction Company, of Kansas City, who built the structure:

"Referring to your letter relative to the Galveston Causeway, we quote below our first information relative to the damage. This information was in a wire from our representative, John Springer, at Galveston, dated Aug. 21 at 8.45 p. m.

"The protecting slabs and handrails on the protected roadway did not stand the force of the waves, which went over the top of the protection and scooped the sand out, letting the slabs collapse. Every sheet pile and the sheet-pile caps, including all the rods, are in place so perfectly that the water is standing 2 ft. higher between the concrete pile walls than outside. The arches are all in perfect condition, including the sand fill on the arches. There is no damage at all to the handrail on the arch bridge, and no damage to the lift bridge."

"We quote the following extracts from Mr. Springer's personal letter of Aug. 19:

"The storm was more severe than in 1900; the water was higher and lasted longer. There was very little loss of life and property damage was not so heavy as in 1900. The bath houses at the beach washed away, and the casino building was wrecked. All the larger buildings here weathered the storm in fine shape and there was less damage at the Galvez than there were at the Rice in Houston."

"We have not received any photographs as yet from Mr. Springer, but shall forward any that we may receive. We are, however, sending three construction views [space did not permit showing them] which show a little of the protected roadway, of which there are 3696 ft. on the mainland end and 4523 ft. on the Galveston end. The concrete slabs extended on the side slopes from the concrete caps on top of the concrete piles up to the roadway, but it was from the top of this roadway that the sand was scooped by the waves, allowing the concrete slabs and handrail to collapse."

PLOWING UP THE SUBGRADE and re-rolling to get an even compactness on country roads on which concrete is to be laid is a practice recommended by J. H. Mayne, consulting engineer, of Council Bluffs, Iowa. Many specifications call for non-disturbance of the original earth when shaping the subgrade. On many country roads the wheel-track area has been compacted for years much more than the sides. Mr. Mayne is of the opinion that it is impossible to compact the sides by rolling to the same degree as the center space, and that there is a likelihood of future settlement under load at the sides and consequent longitudinal cracks.

NEWS OF THE WEEK

Passing Events in the Civil Engineering and Contracting Fields

Draw Span of Harlem River Bridge Floated to Place

On Sunday morning, Aug. 22, the new double-deck 1100-ton draw span for the bridge which carries the Second and Third Avenue elevated lines in New York City across the Harlem River was floated into place. The old span was removed, after being lifted on two barges, at 5.45 a. m. The first train was run over the new span at 12.42 p. m. Four barges were used to float the new span, and twenty-four sand jacks were used to help the tide in lowering it into place. The entire operation was carried out to schedule without mishap. The placing of the two new approach spans for this bridge was described on page 341 of the Engineering Record for March 31, 1915. An account of the operation of putting in the draw span will appear in an early issue of the Engineering Record.

Train Derailed in Tunnel Knocks Lining Down on Itself

A section of the timber lining of a short tunnel near McCorkle, W. Va., on the Coal River Railway, a branch of the Chesapeake & Ohio Railway, connecting with the main

line at St. Albans, W. Va., was knocked down Aug. 17 by a derailed passenger train, crushing through part of the train and killing five people. The accident was caused by a broken rail outside the tunnel, 90 ft. from the portal; the rail was piped through the center of the head, in such a way that it could not have been detected by ordinary inspection. The tunnel is 360 ft. long, on an 8-deg. curve, and is lined with timber except for short distances at each end.

The train consisted of an engine, express car, mail and baggage car and three coaches. The engine and forward truck of the express car passed over the broken rail safely, but the rear truck left the track and the derailed coaches knocked down 23 lin. ft. of the timber lining, allowing the timber arch and packing above to fall and crush through one end of one of the coaches.

Plans for Hetch Hetchy Railroad Almost Completed

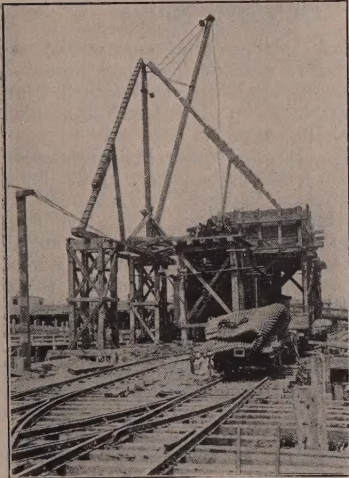
Plans are almost completed by the city engineer's forces in San Francisco for the remaining 58 miles of railroad to connect the Hetch Hetchy dam site with the Sierra Railway, and it is expected that contracts for construction will soon be let.

Court Orders New York Board to Approve Subway Contract

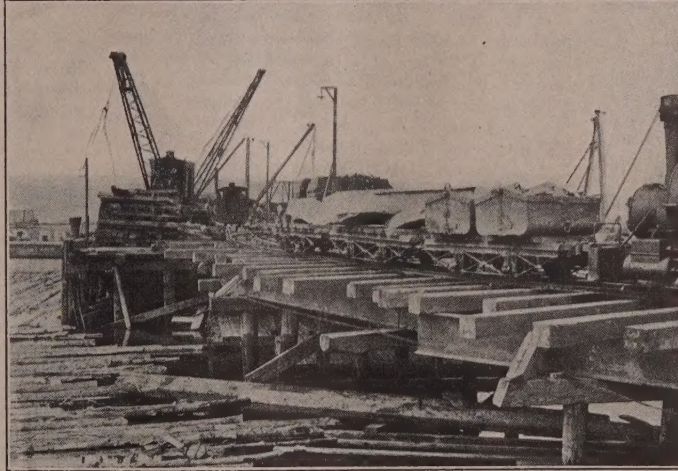
A peremptory writ of mandamus, issued Aug. 23 by Justice Shearn of the New York Supreme Court, orders the Board of Estimate of New York City to "reconvene forthwith" and approves in its original form the contract awarded to the Holbrook, Cabot & Rollins Corporation for the construction of the section of the Broadway subway at Times Square. The Board, as noted on page 241 of the Engineering Record for Aug. 21, had omitted a clause relating to payment for extra work by supplementary agreement between the contractor and the Public Service Commission and had then attempted to approve the contract in its modified form. The contractors refused to accept the modified contract on the ground that it was invalid, and brought the court action referred to. The Court agreed that the Board of Estimate had no power to alter the contract after bids had been received. In commenting on the action of the board, the Court said in part:

"The course that has been pursued in respect to this contract is, to say the least, most unbusinesslike. If it were to prevail, no bidder for city work could ever know where he stood. There must be some reasonable certainty in

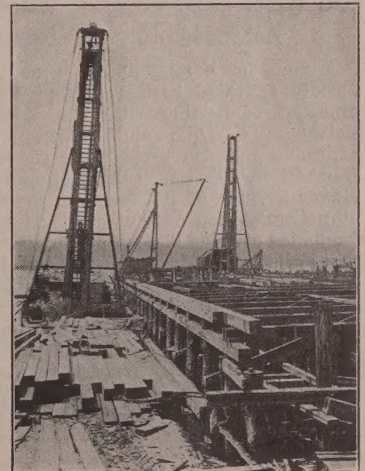
Work Now in Full Swing on New York City's Forty-sixth Street Pier



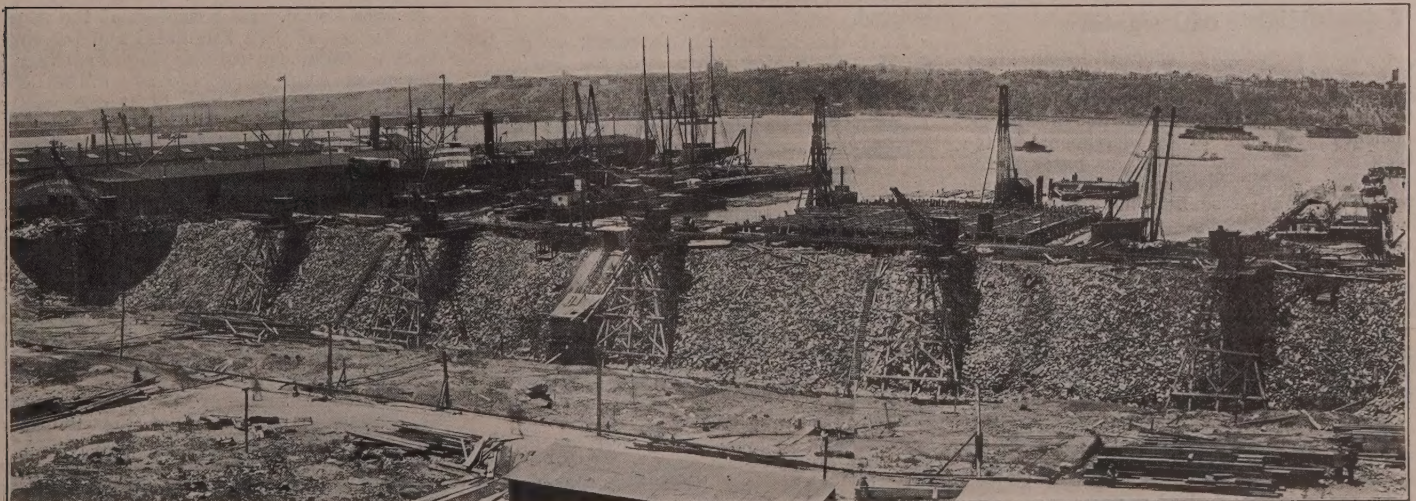
MIXING PLANT IS READY



ROCK IS DISPOSED OF FROM OLD FORTY-FIFTH STREET PIER



DRIVERS BUSY ON NEW PIER



NEW PIER IN RIGHT CENTER, DISPOSAL PIER TO LEFT OF IT—DERRICK BOAT BETWEEN TWO CRANES AT RIGHT STARTING TO ERECT MIXING PLANT

these large matters, and in the end the city would be the loser by having the courts approve such methods, as are here disclosed, where, after public hearings on the form of contract, advertisement of its terms, invitations to bid thereon and an award to the lowest bidder, an attempt was made to coerce the contractor into accepting a materially different contract."

Referring to the merits of the alternative method of paying for extra work to which the Board objected, the Court said:

"It is true that an alternative provision in the contract also furnishes an opportunity for favoritism and jobbing. The new policy attempted to be put into effect by the Board of Estimate may be wise, in spite of the fact that the alternative plan has worked well and has been generally considered most satisfactory. But this would have no bearing on the legal question, many times decided, that the contract cannot be materially changed after advertising. It cannot be seriously contended that the Board of Estimate has the power to attach to a contract a condition that will invalidate the contract."

The Justice ordered that the contract be delivered and that work go forward at once. He pointed out that under the terms of the original contract, the contractor was bound to accept payment for extra work under the clause stricken out by the Board, or under another clause which the Board approves, providing payment at cost plus 10 per cent, at the option of the Public Service Commission. The Justice held that the Public Service Commission could agree to exercise that option in favor of the cost plus 10 per cent clause pending a settlement of the case in the higher courts, in case the Board of Estimate decided to appeal from the court's decision.

Proposes City-Owned Tunnel for All Baltimore Railroads

A plan for a municipally owned and electrically operated system of tunnels and approaches connecting with the Pennsylvania, Baltimore & Ohio and Western Maryland railroads and the proposed city belt line on Key Highway, was submitted Aug. 19 by Mayor Preston of Baltimore to the City Planning Commission of that city. The plan contemplates a union station at Biddle Street and the Fallway. The tunnel would have easy curves and a maximum grade of 0.5 per cent, as compared with 1.2 per cent for the Pennsylvania and 1.5 per cent for the Baltimore & Ohio. It would also shorten these lines a mile and half a mile respectively, and afford an entrance for any new railroad coming to the city. The total estimated cost of tunnel, approaches and equipment is given as \$17,369,000.

New Mexico Water Board Upholds Rights of Irrigators

A decision recently rendered by the New Mexico State Water Board declares that the using of the upper waters of the Rio Grande for irrigating purposes will not affect the efficiency nor work to the detriment of the Elephant Butte dam and other water rights which depend for their supply on the lower waters of that stream. The action of the board is the result of an appeal by the Arlington Land Company of Rio Arriba County, from an earlier ruling by the State engineer, and confers upon the areas drained by the upper waters of the Rio Grande privileges which, under former State and Government rulings, it was claimed, had been curtailed or restricted, to the detriment of users in the district.

In its decision the board declared in part: "There is water in the Rio Grande sufficient for supplying the needs of the United States under its projects and also sufficient to provide the amount desired by the Arlington Land Company under its applications, the

amount covered by such applications being less than one-third of the average yearly surplus of water. We see no reason why the beneficial use of this surplus water should be either prevented or delayed." The decision also states that if the Government "considered that the applications of the Arlington Land Company were detrimental to its proposed appropriations of waters of the Rio Grande, it was under obligations to file a formal protest in the office of the State engineer and set up and define the grounds on which it believed its right to rest, the same as any individual appropriator of water would be obliged to do under the same conditions."

New England Waterworks Convention Will Visit Kensico Dam

The program for the thirty-fourth annual convention of the New England Waterworks Association, to be held at the Waldorf-Astoria Hotel, New York City, Sept. 7, 8 and 9, was made public this week. Twenty papers are scheduled for presentation, among them one on "The Present Status of the Catskill Water Supply for New York City," by J. Waldo Smith, chief engineer, Board of Water Supply. Two sessions are to be devoted to matters of interest to waterworks superintendents. There will be a boat ride up the Hudson River on the afternoon of Sept. 8, and a trip to the Kensico dam of the Catskill aqueduct is scheduled for Sept. 9. The convention arrangements have been made by a committee consisting of Alfred D. Flinn, chairman, Charles W. Sherman, William W. Brush, Francis F. Longley, Henry B. Machen, Fred S. Bates and Dennis F. O'Brien.

Chicago Excursion Boat Tested

Sand bags, equivalent to the weight of 4687 passengers, 1000 more than permitted by law, were piled on one side of the Christopher Columbus, a whaleback pleasure steamer in the Chicago River, without tipping it over. The test was made, Aug. 5, as an experiment in stability, under the direction of Capt. James Lee Ackerson, U. S. naval constructor, and Edward C. Gillette of the U. S. Lighthouse Bureau. After the sand weighing 375 tons was transferred to the three decks the vessel steamed out into the lake with its load of 250 persons including city and federal officials. It was announced that the boat listed at an angle of 10 to 12 deg. The ballast tanks were empty and the metacentric height of the vessel was lowered from 64 to 36 in.

Personal Notes

First-Lieut. Joseph C. Mehaffey, Corps of Engineers, U. S. A., has been detailed as a member of the Board of Road Commissioners for Alaska, succeeding Capt. Glen E. Edgerton, relieved.

J. H. Lendi, formerly assistant to A. G. Carlson, mechanical engineer of the Universal Portland Cement Company, 208 South La Salle Street, Chicago, has been appointed electrical engineer in the engineering department of the company.

E. S. Mudge, formerly division engineer for the Atchison, Topeka & Santa Fé Railway at Wellington, Kan., has been appointed assistant engineer in charge of valuation of the company's Western lines, with headquarters at Amarillo, Tex.

Harvey C. Miller, consulting and constructing engineer specializing in reinforced concrete, who represents the "American System of Reinforcement," has moved his offices from 1 Madison Avenue to 40 West Thirty-second Street, New York City.

J. Borge, formerly chief engineer of the National Incinerator Company of New York City, and of Lewis & Kitchen of Chicago and Kansas City, has organized and is president of the Borge Incinerator Corporation, with

office in the Flatiron Building, New York City. In addition to contracting for the installation of incinerators and industrial furnaces the corporation will engage in practice as consulting engineers in these branches.

The Harrisburg Water Laboratories have been organized at Harrisburg, Pa., for the chemical and bacteriological examination of water, sewage, trade wastes and other associated substances. The organization consists of Leslie McCreath, junior member of the firm of Andrew S. McCreath & Son, analytical and consulting chemists, Harrisburg, who still retains his interest in that firm; Dr. George R. Moffit, city chemist and bacteriologist, pathologist to the Harrisburg Hospital and head of the Moffit Bacteriological Laboratory, and Farley Gannet, whose resignation from the office of engineer to the State Water Supply Commission of Pennsylvania to engage in private practice as consulting engineer was noted in these columns July 24.

G. R. G. Conway, whose resignation from the office of chief engineer of the British Columbia Electric Railway Company, Ltd., and the Vancouver Power Company, was noted in these columns July 10, has opened offices at the Royal Bank Building, Toronto, Canada, for consulting practice in civil and hydraulic engineering. Mr. Conway was educated in Great Britain and practised engineering in that country until 1907, when he was appointed chief engineer of the Monterey Waterworks & Sewer Company, Ltd., and of the Monterey Railway, Light & Power Company, Ltd., in Mexico. His term of service with the Canadian companies covered a period of very rapid development of their properties. The Lake Coquitlam dam was constructed under his direction, as was the 130-ft. dam on the Jordan River, Vancouver Island.

Obituary Notes

J. Edward Bering, who constructed the Horseshoe Curve and the first long tunnel on the Pennsylvania Railroad, in Western Pennsylvania, was killed in an automobile accident at Decatur, Ill., Aug. 19. He was 86 years of age. Mr. Bering began his professional career on the engineering forces of the Pennsylvania Railroad in 1848. He attained the grade of principal assistant in the civil engineering department, in which capacity he laid out the Horseshoe Curve, previous to his resigning from that company's service to become associated with the Erie Railroad. During his lifetime, he also served in engineering capacities on the Bald Eagle Valley, the Sterling Mountain, the St. Croix & Lake Superior, the Allegheny Valley, the Boston, Hartford & Erie, the New York Central & New Haven and the Pekin, Lincoln & Decatur lines. He was one of the first promoters of the oil industry in the United States and was directly responsible for the discovery of coal in the vicinity of Decatur in 1876.

Mendes Cohen, past president of the American Society of Civil Engineers and for many years a prominent railway engineer, died in Baltimore, Aug. 13, at the age of 84. His first railway service was in the locomotive works of Ross Winans at Baltimore. In 1851 he was appointed assistant engineer on the forces of the Baltimore & Ohio Railroad, in which service he remained for about 4 years, when he was appointed assistant engineer on the Hudson River Railroad. He was appointed superintendent of the Ohio & Mississippi Railroad in 1861. He left this company to become connected with the Philadelphia & Reading. In 1872 he was appointed president of the Pittsburgh & Connellsville Railroad. He became a member of the American Society of Civil Engineers in 1867 and was elected president of the society in 1892. He served as chairman of the Baltimore Sewerage Commission from 1893 to 1894 and was a member of the board appointed by President Cleveland, in 1894, to examine and report on a route for the Chesapeake & Delaware ship canal.